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A REVISION OF THE AMERICAN ARCTIC HARES

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At the time Nelson's monograph of "The Rabbits of North America" was published (1909), specimens of Arctic hares were so few that it was impossible to treat the group adequately. Since then many expeditions have visited the north country and so many specimens of these boreal hares have been collected that it now is possible to present a fairly complete synopsis of the American species.

In December, 1933, after assembling in the National Museum a large amount of pertinent material borrowed from various American museums, Dr. Nelson undertook a revision of the group, and in March, 1934, he published descriptions of 4 new forms. His studies, unfortunately, were terminated by his death on May 19, 1934, and shortly thereafter his notes were turned over to me to carry the revision to completion.

In addition to his detailed studies of the characters of the various races, Dr. Nelson entered into correspondence with many persons who had special knowledge of the habits and distribution of the Arctic hares, and obtained from them much new information. He also had translations made of numerous articles published in Danish, from which quotations are made in the present paper.

The principal credit, therefore, for the results here presented is due to Dr. Nelson, whose interest and enthusiasm for detailed research remained unflagging to the last. At the time of his death he had assembled a large amount of data but had not completed his manuscript treatment of the group. I have checked all his conclusions and remeasured all the skulls in order to obtain uniformity of treatment. I have been obliged to differ with his conclusions in only one important particular—the uniting of the hares of east Greenland, described by him under the name *Lepus arcticus persimilis*, with *L. arcticus groenlandicus* of the west coast.

Acknowledgments.—It is a pleasure to record here the main sources of the new material made available for this study and to make acknowledgment of the courtesies received. Dr. R. M. Anderson, of the National Museum of Canada, made a large collection of hares in the Coronation Gulf region of northern Canada; in addition he has loaned the Soper collection from Baffin Island and other material in his custody, and furnished many notes and suggestions. Dr. Morten P. Porsild, of the Danish Arctic Station in west Greenland, some years ago obtained for the Biological Survey series of specimens from southern and southwestern Greenland which have proved invaluable in showing relationships and the development of characters. Mr. Charles M. B. Cadwalader and Mr. Wharton Huber, of the Academy of Natural Sciences, Philadelphia, supplied the only available specimens from eastern Greenland, as well as the type series of *groenlandicus*. Dr. H. E. Anthony, of the American Museum of Natural History, sent series from various parts of the Arctic. Dr. A. Avinoff and Mr. J. K. Doutt, of the Carnegie Museum, loaned the collection made by Dr. George Miksch Sutton on Southampton Island and important specimens from Labrador and Alaska. Dr. Glover M. Allen, Museum of Comparative Zoology, furnished a series of the Newfoundland race. Dr. Lee R. Dice, of the Museum of Zoology, University of Michigan, loaned a fine series from Greenland. Mr. Alfred J. Lomen, of the Northwestern Livestock Company, obtained and forwarded a number of important skulls from Alaska, and photographs of the Alaska tundra hare. The photographs of hares in east Greenland were supplied through the courtesy of Dr. Curt Teichert, of the Mineralogisk Museum, Copenhagen.

Altogether more than 400 specimens have been examined. Specimens listed without indication of source are in the U. S. National Museum.

Habits.—In view of the general distribution of these hares, their frequent abundance, and the rôle that they have played as a part of the food supply of Arctic explorers, the scarcity, until recently, of recorded information on their life history is disappointing. The combining of the brief records of the earlier explorers with the excellent notes from some of the recent expeditions reveals that the big hares of the American boreal region are among the most interesting inhabitants of that barren area. The best of these accounts relate to the hares of Ellesmere Island and eastern Greenland, those from Greenland being published in German, Swedish, and Danish. In those regions the hares are the largest representatives of their kind, are snow white throughout the long winter, and are only a little less white during midsummer (July and August), when they have a slight wash of cinnamon or gray on parts of the head and back. These animals with white coats throughout the year range to the extremes of the northernmost known lands, beyond 83 degrees latitude, and they have responded to their environment by developing extraordinarily long, obliquely projecting incisors that operate like the points of tweezers or pliers in extracting from the packed snow the dwarfed plants upon which they feed.

The habits of the hares of east Greenland have been described in interesting detail by several authors, especially by Manniche (1910) and Pedersen (1926). From these accounts the following facts have been extracted. The hares inhabit chiefly the rocky slopes of the mountains, parts of which may be kept free of snow by wind action. Only in the severest part of the winter, when food is difficult to obtain, do they frequent the shore plains and marshes. The animals sometimes dig long channels through the snowdrifts, but ordinarily they need no other shelter than that afforded by a rock or a mere depression in the snow.

When resting, the hares sit crouched, with the ears half erect and eyes nearly closed. In this position, surrounded as they are by snow,it is extremely difficult to detect them, even at a short distance.

Manniche (1910), describing the actions of a group of the animals when frightened, wrote: "In rapid jumps they hurried up the hillside—never the opposite way—moving

on the tip toes of the hind limbs, while the fore limbs either dangled in the air or were kept close to the breast.

"The vigilant animals danced among each other—still without using their fore limbs—looking out for the nature of the danger, while they turned their ears forward and strongly scented by means of their nostrils. Not the weakest vibration in the air did under these circumstances escape the attention of the animals. I feel sure that the hares in danger more trust their sense of hearing and smelling than their sight. I convinced myself at many other occasions that the hare's sight is not very strong.

"If the frightened hares considered the danger to be only slight—as they for instance did when I kept quiet—they soon gave up their 'playing kangaroos' and would slowly on all fours jump towards the nearest larger stone to continue their broken off repose. . . ."

The feeding habits of the hares are thus described by Manniche:

"Crusted snow, through which the hare is not able to penetrate with the fore legs or the nose in usual way, is forced in the following manner: Having first—by aid of its surprising sharp sense of smell—assured itself where the food can be found, the hare hammers its fore limbs against the snow crust in rapid strong beatings until the crust breaks all over. The animal can then by aid of its nose and nails remove the subjacent loose snow and get at the desired food. I have also seen hares, which, having drummed through the icy snow crust, remove larger pieces of broken ice by means of the mouth in order to make better room to go on with their work."

The Arctic hares are dependent for food upon the few dwarf plants that grow in the frozen regions where they make their home. Chief among these are the creeping willows (*Salix*), crowberry (*Empetrum*), and saxifrage (*Saxifraga*). When food is scarce, the hares sometimes eat moss and withered grass.

A striking characteristic of these hares is their sociability and lack of fear. This is most pronounced in fall and winter when groups numbering up to 100 individuals have been seen. At such times, by avoiding quick movements or loud noises, observers have been able to go among the groups, feed the animals, and even catch them in the hands.

In June and July, however, when the hillsides are bare of snow, the hares are more scattered and then are so shy that often it is difficult to approach them within gunshot. Pedersen stated that his sledge dogs inspired the Greenland hares with great fear. When chased by a dog, they always ran up the steepest slopes, which they did with such skill that no dog was able to catch them.

Near the southwestern corner of Ellesmere Island, however, in a region full of musk-oxen but no wolves, Sverdrup (1904, vol. 2, pp. 181–182) found hares in astonishing abundance. He wrote: "There were such legions of them, and they scurried about so in all directions, along the valley and backwards and forwards, that the dogs became almost unmanageable. It was impossible to keep them in check; they gave chase time after time; and the hares themselves were so dazed that they had not the wit to keep out of the way. They did not appear to be afraid; they hopped about only a few yards in front of the teams. . . . As if to incite the dogs to the utmost, the hares came and settled down a few yards from them, and then stood on two legs and stared at us. . . . After a good deal of trouble we succeeded in driving away the greater number, and were able at last to go on."

Enemies.—Pedersen (1926, p. 162) found the enemies of the Greenland hare to be the Arctic wolf, the Arctic fox, and the snowy owl, the fox holding first rank. Remains of Arctic hares were found in a comparatively large number of fox stomachs examined by him. Once, on the coast of a fiord, he found the remains of a hare freshly torn to pieces by a fox, and on two occasions he found remains of a hare in excrement of the wolf. He was not able to determine exactly the relation of the snowy owl to the hare, since too little material from this bird had passed through his hands.

Breeding.—Pedersen stated that the pairing period of the east Greenland hares is

during the first half of May. On May 8 and 10, 1928, and during the period from May 6 to 10, 1929, 8 males with enlarged testicles were shot on the Liverpool coast and the northern coast of the Nordvest Fiord. About the first days of May, the hares disappeared suddenly from the snow-filled, overgrown slopes on the mountains, where throughout the winter they had lived in troops, and now were seen in pairs.

The first pregnant hare with recognizable embryos was obtained in 1928 on May 20, and in 1929, on May 19; at the end of the month pregnant females were of frequent occurrence. The embryos in most instances numbered 7—more rarely 6. Manniche, however, found 6 to be the normal number—seldom 5 or 7. Young hares the size of rats were seen by him on June 26; Pedersen noted the first new-born young on June 26 and 28.

Feilden (1877, p. 354) stated that in Grinnell Land the number of young found in gravid females varied from 7 to 8. Hantsch collected 2 females at Nettilling Lake, Baffin Island, on June 19, each of which contained 4 grown embryos.

Explanation of cranial measurements.—Measurements of skulls of hares, in millimeters, have been taken as follows:

Greatest length.—From anterior face of upper incisors to posterior border of interparietal.

Basilar length.—From posterior edge of alveolus of I^2 to inferior border of foramen magnum.

Length of nasals.—Greatest diagonal length of longest nasal.

Width of nasals.—Greatest breadth of nasals near posterior termination.

Depth of rostrum.—Measured with one bar of vernier calipers resting on the concavity of each maxillary in front of anterior premolars, the upper bar held as nearly perpendicular as possible.

Cranial breadth.—Greatest breadth of braincase measured across squamosal swellings behind zygomatic arch.

Zygomatic breadth.—Greatest breadth across squamosal portion of zygomatic arch.

Maxillary tooth row.—Length of maxillary tooth row measured at alveolar border.

Lepus arcticus Ross

General characters.—The hares of this species are most nearly related to the varying or snow hares of the Old World. *Lepus arcticus labradorius* is about the size of *Lepus timidus timidus* of the Scandinavian Peninsula and the skulls of the two species are closely similar, differing only in minor details of proportion. Externally, however, all the races of *timidus* apparently are darker and more brownish (less grayish) than the races of *arcticus*. The more northern races (*monstrabilis* and *groenlandicus*) are larger and have the upper incisors longer and less recurved; their pelage is white throughout the year.

Compared with *Lepus townsendii*, all the races of *arcticus* are of stockier build with relatively shorter ears and tail, and more dense, woolly fur. Their skulls are characterized by a relatively broader braincase and by a pronounced depression in the anterior part of the frontals.

Lepus arcticus arcticus Ross

Arctic Hare

Lepus arcticus Ross, Voyage of Discovery, ed. 2, vol. 2, appendix 4, p. 151, 1819. Type from Possession Bay, Bylot Island, latitude 73° 37′ N. Collected September 1, 1818, by John Leach. (See Ross, Voyage of Discovery, orig. ed., pp. 177–179, 1819.)

Lepus glacialis Leach, in Ross, Voyage of Discovery, ed. 2, vol. 2, p. 170, 1819. Same type and locality as for *arcticus*.

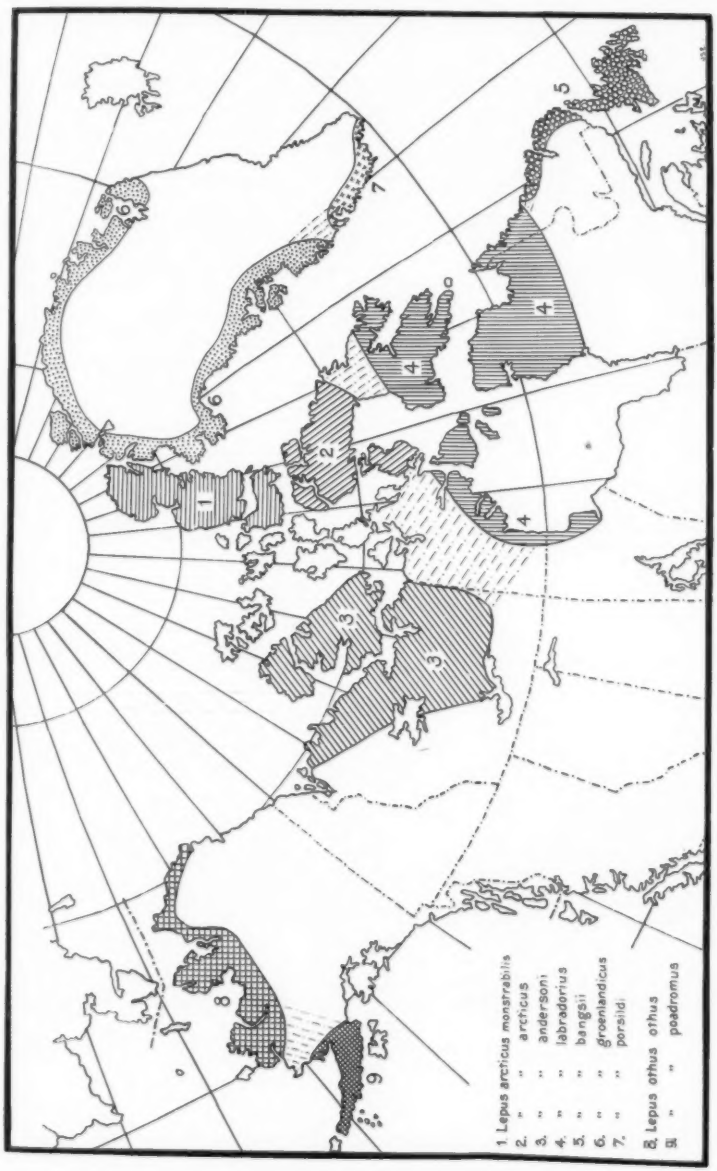
1. Lepus arcticus monstrabilis
2. " " arcticus
3. " " andersoni
4. " " labradorius
5. " " bangsii
6. " " groenlandicus
7. " " porsildi
8. Lepus othus othus
9. " " poadromus

FIG. 1. Distribution of Arctic hares

Lepus arcticus arcticus Soper, Bull. 53, Biol. Ser. 15, Canada Dept. Mines, pp. 59–63, 1928 (part—specimens from Pond Inlet region).

FIG. 2. Arctic hares in southern Strindberg Land, East Greenland. (Photos by Dr. Curt Teichert.)

Geographic distribution.—Definitely known only from specimens examined from near Pond Inlet, northeastern Baffin Island, and from Bylot Island. It unquestionably occupies most, if not all, of the northern half of Baffin Island and possibly also Boothia and Melville peninsulas and Somerset Island.

External characters.—Of medium size; color, in winter, pure white except for small black tips to ears; in summer, pale smoke gray.

Cranial characters.—Skull larger than that of *labradorius*, with heavier rostrum but relatively narrow braincase; upper molars heavier; upper incisors less strongly decurved (in adults).

Color.—Summer pelage (one specimen, Egukjuak, northeast Baffin Island, August 26): Nose and sides of face pale pinkish buff, shaded with pale smoke gray; top of head smoke gray, shaded with fuscous; anterior half of ears smoke gray, washed with pale pinkish buff; general tone of upperparts pale smoke gray, somewhat darkened by the subterminal bands of fuscous; front legs cartridge buff; hind legs white, with a wash of smoke gray; tail white; chin and throat smoke gray; rest of underparts white. *Winter pelage:* Pure white, except for small blackish tips to ears.

Seasonal changes in color.—The type specimen, taken September 1, was said to be white, sprinkled on top of head, neck, and back with blackish brown hairs banded with white, indicating that it had nearly acquired winter pelage.

Records of specimens from other localities probably within the range of *L. arcticus arcticus* afford other dates indicating periods of change: Captain Lyon records a perfectly white hare, August 28, 1921, on Melville Peninsula. At Repulse Bay, August 17, Parry saw a pure white hare and the next day saw another one in dark gray summer coat. A young one killed at that locality on August 22 was in full summer dress; the back was hoary from a mixture of black with white-tipped black hairs and a yellowish-gray underfur; throat, flanks, and thighs of a bluish gray; ears similar to back but darker.

Measurements.—No external measurements, taken in the flesh, are available. A specimen taken at Ponds Inlet, mentioned by Soper (1928, p. 63), weighed 11 pounds; one killed at Winter Island, Melville Peninsula, weighed 8.5 pounds.

Skull measurements.—Average of 5 adults from Pond Inlet and Tulukane Fiord, northern Baffin Island, and Bylot Island: Greatest length, 99 (96.8–100.5); basilar length, 75.2 (73.3–76.6); diagonal length of nasals, 40.4 (39.8–41.2); greatest width of nasals, 20.8 (19.9–22.7); depth of rostrum, 23.5 (22–24.2); cranial breadth, 34.7 (33.8–35.4); zygomatic breadth, 48.5 (47.4–49.7); maxillary tooth row, 18.1 (17.5–18.5).

Remarks.—Until recently no specimens of typical *arcticus* have been available to students, and its real characters have been a matter of conjecture. Fortunately, the work of Soper and others has supplied the National Museum of Canada with a small series of specimens from the district near Pond Inlet, northeast Baffin Island, and one specimen from Bylot Island. During his explorations on Baffin Island Mr. Soper spent from August 21 to September 3, 1923, at the R. C. M. Police headquarters at Pond Inlet. Although he hunted persistently he saw only one hare, apparently a young one in the gray coat. Sergeant Joy informed him that hares had been common during the autumn and winter of 1922–23 in the vicinity of Patricia River, to the west of the station, but on Sptember 1, 1923, although signs were abundant, no animals could be found there. Corporal McInnes, R. C. M. P., in March 1926, wrote Mr. Soper that hares were present nearly everywhere in the district adjacent to Pond Inlet. Soper's failure to find hares during his visit to that locality illustrates the fact brought out by his observations farther south on Baffin Island and by other observers elsewhere in the north that the numbers of Arctic hares fluctuate locally from season to season and from year to year.

The limits of the range of typical *arcticus* are not definitely known. This race is most nearly related to *labradorius*, with which doubtless it intergrades in southern Baffin Island. It probably intergrades also with *andersoni* in northern Keewatin or Melville Peninsula, but no specimens from those regions are available. It differs widely in skull characters from *monstrabilis* of Devon Island and Ellesmere Island.

Specimens examined.—Total number, 8, from localities as follows:
Baffin Island: Egukjuak (8 miles east of Pond Inlet), 1[1]; Pond Inlet (Albert Harbor), 2 (skulls)[2]; Tulukane Fiord (18 miles west of Pond Inlet), 4 (skulls)[1].
Bylot Island, 1[1].

Lepus arcticus labradorius Miller

Hudson Bay Hare

Lepus labradorius Miller, Proc. Biol. Soc. Washington, vol. 13, pp. 39–40, May 29, 1899. Cotypes from Fort Chimo, Ungava, Canada; adults, U. S. Nat. Mus., skull no. 23132 and skin no. 14149; collected by L. M. Turner, September 28, 1882.

Lepus arcticus canus Preble, North Amer. Fauna, no. 22, pp. 59–61, October 31, 1902. Type from Hubbart Point, west coast Hudson Bay, Keewatin, Canada; no. 106860, ♂ adult, U. S. Nat. Mus. (Biol. Surv. collection); collected by E. A. Preble, August 7, 1900. Under this name Preble included also the Arctic hares now classified under *Lepus arcticus andersoni*.

Lepus arcticus arcticus Nelson, North Amer. Fauna, no. 29, pp. 61–64, August 31, 1909; in part.

Lepus arcticus Allen and Copeland, Jour. Mamm., vol. 5, p. 12, 1924.

Lepus arcticus arcticus Soper, Bull. 53, Biol. Ser. 15, Canada Dept. Mines, pp. 59–63, 1928; in part. All that part of this article on the hares of southern Baffin Island is referable to *labradorius*.

Lepus arcticus arcticus Sutton and Hamilton, Memo. Carnegie Mus., vol. 12, pt. 2, pp. 71–79, 1932 (not of Ross).

Geographic distribution.—Southern half of Baffin Island; Southampton Island; both shores of Hudson Bay, south to Great Whale River and York Factory; and northern Ungava, south on the Atlantic coast to about latitude 56°.

External characters.—Closely similar in color to *arcticus*, but slightly darker, especially on the rump.

Cranial characters.—Skull similar to that of *arcticus*, but total length averaging less, owing to the less projecting upper incisors; braincase slightly broader; rostrum lighter and shallower; upper molar series narrower, and averaging shorter; upper incisors more strongly decurved.

Color.—Summer pelage (Fort Chimo, July 6): Head smoke gray, with a faint buffy tinge; general tone of upperparts smoke gray, the hairs buffy white at the tips, hair-brown subterminally; ears blackish brown anteriorly, white posteriorly, with brownish tips; legs white, with a wash of smoke gray; tail white.

The type, taken September 28, is similar to the July specimen, except that the nose is pale pinkish buff, and sides of head washed with the same; ears blackish brown, the hairs tipped with whitish. A specimen from Dorset, Baffin Island, August 29, is considerably paler than the July specimen from Labrador, being pale smoke gray on the dorsal surface, and the ears more whitish. The young are similar to the adults in summer pelage. *Winter pelage:* Pure white, except for black tips to the ears.

Seasonal changes in color.—On Southampton Island, 6 specimens taken May 20 and 21 by Sutton were white but showing the summer gray in spots and blotches; the ears were still white; one was becoming gray about eyes. On June 13 several individuals seen were mainly white but with broad blotches of gray summer fur showing. Soper states that on southern Baffin Island the change from winter to summer pelage takes place during June; the latest dates on which he observed white individuals were June 20 and 24.

The autumn molt begins about the last of August. A specimen from Blacklead Island, Cumberland Sound, taken August 30, is all white, except for a small patch of

[1] Nat. Mus. Canada. [2] Amer. Mus. Nat. Hist.

gray on top of the head, and one from Cape Dorset, Baffin Island, September 7, is in similar condition. Specimens from Koksoak River, Hudson Bay, September 15, and from Cape Mugford, Labrador, September 27, are white with a wash of gray on the back and a solid gray patch on the head.

A careful examination of specimens of this race taking on winter pelage indicates that the change is accomplished by a gradual growth of new hairs, the summer coat being shed more gradually than is the winter coat in the spring.

Measurements in the flesh.—Average of 3 adults from Labrador and Ungava: Total length, 558 (480–600); tail vertebrae, 45 (40–48); hind foot, 153 (150–157). Average of 11 adults from southern Baffin Island: Total length, 580 (535–663); tail vertebrae, 42.5 (34–55); hind foot, 158 (150–170).

Weight.—Eight specimens weighed by Soper in the Cumberland Sound region, Baffin Island, ranged from 6 to 7 pounds (average 6.33). A female taken by Seton (1929, vol. 4, p. 668) at Aylmer Lake in August weighed 9.75 pounds.

Skull measurements.—Average of 7 adults from the type locality: Greatest length, 95.4 (94.1–96.2); basilar length, 72.2 (71.6–73); diagonal length of nasals, 40.2 (39.7–41); greatest width of nasals, 20.4 (19.3–21.3); depth of rostrum, 22.2 (21.6–22.7); cranial breadth, 35.3 (34.7–35.9); zygomatic breadth, 48.5 (47.7–49.7); maxillary tooth row, 16.7 (16.2–17.2).

Remarks.—The Hudson Bay hare is closely related to typical *arcticus*, with which race it intergrades in southern Baffin Island. Measurements of a large series of skulls from the Cumberland Sound region demonstrate that the hares of that region are referable to *labradorius*. The skulls average practically the same in length as a series of typical *labradorius*, but approach to *arcticus* is shown by their slightly narrower braincase, deeper rostrum, and longer tooth row. A series of skulls from Bowdoin Harbor, southwestern Baffin Island, however, agrees in most measurements with *labradorius*, except that the upper incisors are slightly less decurved. Skulls from Southampton Island agree closely with those of *labradorius*; a series of 5 from the west coast of Hudson Bay clearly is referable to *labradorius*, differing only in having a heavier rostrum and longer tooth row.

Measurements of a series of skulls from the coast of Labrador show that typical *labradorius* occurs there, south to about 56 degrees latitude, beyond which point intergradation with *bangsii* takes place. Only one summer skin is available from the whole Labrador coast—that from Solomon's Island, near Davis Inlet—and that clearly is referable to *labradorius*.

Specimens examined.—Total number, 144, from localities as follows:

Baffin Island: Bowdoin Harbor, southwest coast, 6 (skulls)[1]; Camp Kungovik (west coast, latitude 65° 35′ N.), 1[2]; Cape Dorset, 6[2, 3]; Cumberland Sound, 56 (Blacklead Island, 1[2]; Nettilling Fiord, 3[2]; Niantilik, 2; Nunata, Kingua Fiord, 11 (skulls)[2]; Pangnirtung Fiord, 39 (skulls))[2]; Frobisher Bay (Weddell Harbor), 1[4].

Keewatin: Cape Fullerton, 4 (skulls)[2]; Southampton Island, 13 (1 skin with skull; 12 extra skulls)[5].

Manitoba: Fort Churchill, 2; Hubbart Point, 2.

Quebec (Ungava): Belcher Islands, Hudson Bay, 2[6]; Fort Chimo, 15 (6 skins[6]; 9 odd skulls)[2]; Great Whale River (Hudson Bay), 1[6]; Koksoak River (mouth), 1[6]; Nastapoka River (Hudson Bay), 1[6]; no locality (probably vicinity of Ungava Bay), 10 (skulls).

Labrador: Cape Mugford, 1[6]; Nain, 1 (skull)[1]; Ramah, 20 (skulls)[1]; Solomon's Island (near Davis Inlet), 1 (skin).

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[1] Mus. Comp. Zool.
[2] Nat. Mus. Canada.
[3] Amer. Mus. Nat. Hist.
[4] Field Mus. Nat. Hist.
[5] Carnegie Mus.
[6] U. S. Nat. Mus.

Lepus arcticus bangsii Rhoads

Newfoundland Hare

Lepus glacialis Bachman, Jour. Acad. Nat. Sci. Philadelphia, vol. 7, pp 285–301, 1837 (part—not of Leach, 1819).

Lepus arcticus bangsii Rhoads, Amer. Nat., vol. 30, p. 236, March, 1896 (author's separates published February 20, 1896). Type in Mus. Comp. Zoöl. (no. 3752, Bangs collection), collected August 3, 1895, at Codroy, Newfoundland, by Ernest Doane.

Geographic distribution.—Newfoundland and the treeless coast belt of Labrador from the Strait of Belle Isle north to about latitude 55°; now restricted in Newfoundland to bare hill tops and exterminated in parts of the Labrador coast.

External characters.—About the size of typical *arcticus*; larger than *labradorius*; coloration in summer pelage darker and more buffy (less grayish) than in the other races of *arcticus*; rump distinctly darker than body; ears mainly dark brown, with little white.

Cranial characters.—Skull about the size of that of *arcticus*; upper incisors more recurved (about as in *labradorius*); slightly larger than that of *labradorius*; smaller than that of *andersoni*; upper molars as in *labradorius*—smaller than in *arcticus* and *andersoni*.

Color.—Summer pelage (Newfoundland, September 15): Head light drab, shaded with pale pinkish buff, strongest on sides of face; general tone of upperparts about light drab, becoming smoke gray on the sides; tips of hairs on back buffy white, the subterminal bands hair brown and the basal portion dull white, tinged with pinkish buff; rump with a large patch of fuscous; ears mainly blackish brown, with a small area of white on posterior surface; front legs rather heavily washed on upper surface with drab or buff; hind legs similar; the hind feet mainly white, with small patches of drab. A specimen from Newfoundland, taken August 2, is more grayish (less drabby) in general tone of the upperparts—about smoke gray. *Winter pelage:* Entirely pure white, except for small black tips to the ears.

Seasonal changes in color.—In the first account of this race—that of Bachman (1837, pp. 288–301)—a specimen taken August 15, 1833, by Audubon at St. George's Bay, Newfoundland, was said to be changing from summer to winter fur. There was a large spot of pure white, nearly a hand's breadth, on the back extending nearly to the tail, and three or four white spots, about an inch in diameter, on the sides. This apparently is an unusually early date for the molt to begin, for in the Bangs collection is a specimen, taken September 15, in full summer coat and also two specimens, taken October 12 and 16, that are still drab-gray on the body, with blackish brown ears.

Measurements in the flesh.—Average of 8 specimens from Newfoundland: Total length, 591 (568–626); tail vertebrae, 61.3 (45–73); hind foot, 164 (158–174); ear, 85.1 (82–89).

Weight.—The specimen collected by Audubon at Bay St. George, the middle of August, 1833, in poor condition, weighed 7.5 pounds. Doubtless this weight is exceeded in full-grown healthy individuals.

Skull measurements.—Average of 6 adults from Newfoundland: Greatest length, 98 (97.1–99.9); basilar length, 76 (73.9–79.4); diagonal length of nasals, 41.9 (41–43.9); greatest width of nasals, 22 (20.6–25.1); depth of rostrum, 23.2 (22.4–24.7); cranial breadth, 35.6 (34–36.2); zygomatic breadth, 48.6 (47.4–49.8); maxillary tooth row, 18 (17–20).

Remarks.—In Newfoundland the Arctic hares reach the southernmost limit of their range in America. In early days these hares were reported to have been numerous in Newfoundland, but it is recorded that about 1864 the Hon. Stephen Rendell introduced snowshoe hares into the island, where they multiplied rapidly and spread into all sections. In a letter dated March 23, 1908, Director James P. Howley, of the Geological

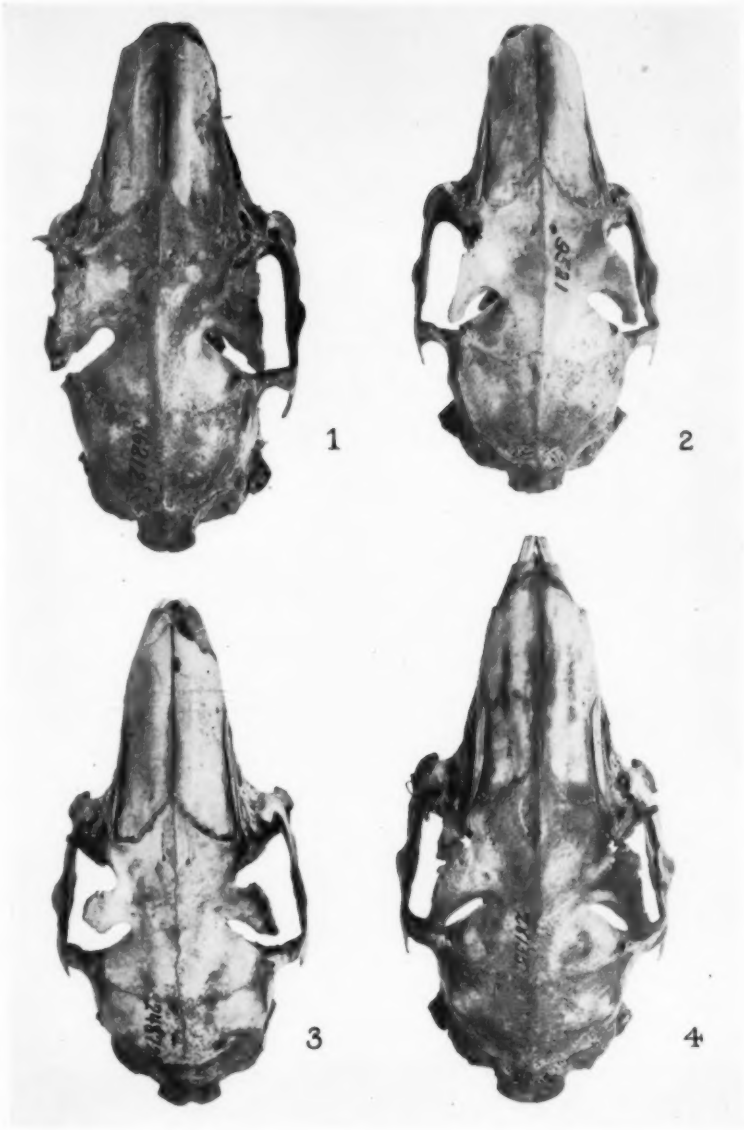

FIG. 3. Skulls of Arctic hares; dorsal view. 1, Lepus othus othus; 2, Lepus arcticus arcticus; 3, Lepus arcticus porsildi; 4, Lepus arcticus monstrabilis.

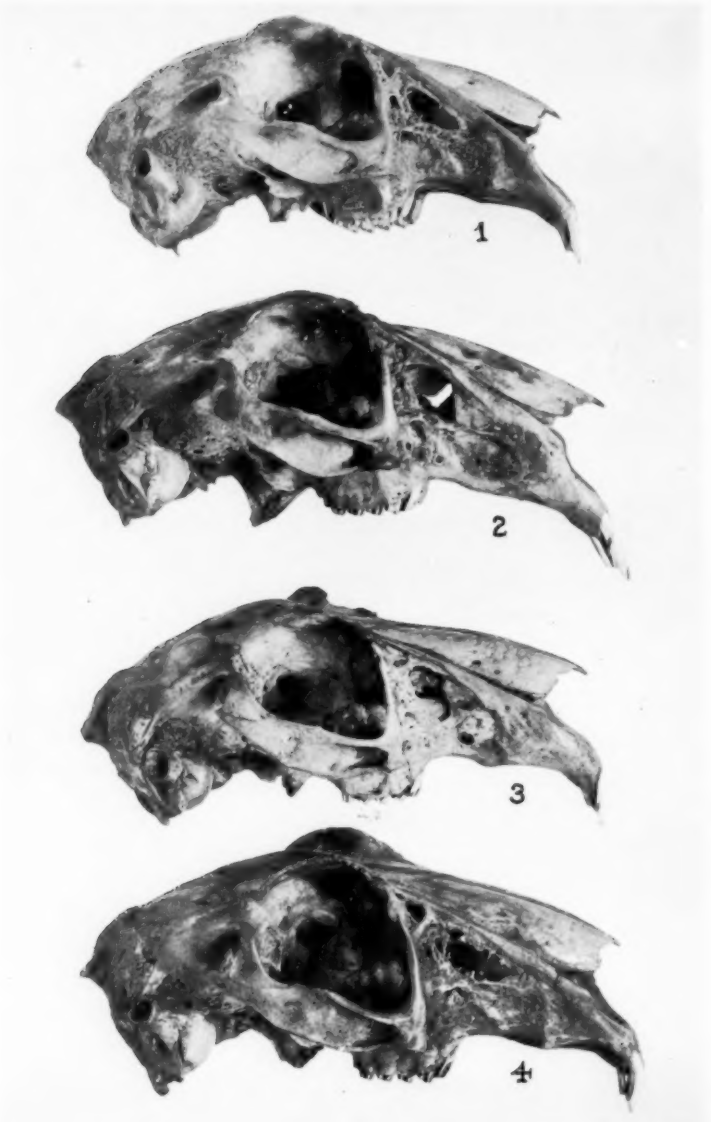

FIG. 4. Skulls of Arctic hares; right lateral view. 1, Lepus arcticus arcticus; 2, Lepus arcticus monstrabilis; 3, Lepus arcticus porsildi; 4, Lepus othus othus.

Survey, wrote: "Undoubtedly they have driven out the large Arctic hare, once fairly plentiful in most parts of the island, but now only to be found on the highest and barest uplands, which do not afford food or shelter for the rabbits [*Lepus americanus struthopus*]. The former are now quite rare."

Ernest Doane, who collected a considerable number of the hares for Outram Bangs, stated that they lived in the high, bare, rocky hills, descending in winter to the open plains, but never entering the woodlands. By day they hid among rocks or under small bushes. As in other parts of their range, the flesh of the hares is highly prized in Newfoundland, being considered much better than that of the varying hare.

A considerable series of skulls from Makkovik and Hopedale, on the coast of Labrador, agrees closely in measurements with those of typical *bangsii*. From that point northward specimens are referable to *labradorius*. Unfortunately, no summer skins are available from the southern coast of Labrador.

Clarence Birdseye, who lived for several years about 1912 at Hamilton Inlet, reports Arctic hares as very scarce in that region, although they formerly were more numerous. He writes that a single individual was killed near Fox Harbor on November 12, 1912.

Specimens examined.—Total number, 45, as follows:

Labrador: Hopedale, 7 (skulls)[1]; Makkovik, 12 (skulls)[1]; Pomialuk, 3 (skulls)[1].

Newfoundland: Bay of Islands, 1; Bay St. George, 13[2, 3]; Codroy, 2[1]; Gafftopsail, 1[3]; Mount St. Gregory, 1; Saint Johns, 5 (skulls).

Lepus arcticus andersoni Nelson

Barren Grounds Hare

Lepus arcticus Preble, North Amer. Fauna, no. 27, p. 206, 1908 (part).

Lepus arcticus canus Nelson, North Amer. Fauna, no. 29, pp. 65–67, 1909 (part—specimens from Franklin and Mackenzie).

Lepus arcticus andersoni Nelson, Proc. Biol. Soc. Washington, vol. 47, p. 85, March 8, 1934. Type from Cape Barrow, Coronation Gulf, Northwest Territory, Canada; female adult, skin and skull, no. 2858, Nat. Mus. Canada; collected August 14, 1915, by R. M. Anderson; original number 511.

Geographic distribution.—Arctic drainage of Mackenzie, Northwest Territory, from Great Slave and Dubawnt lakes to the Arctic coast; west to Kittigazuit, east of Mackenzie Delta; east to Bathurst Inlet and Cambridge Bay and probably farther; also on Victoria and Banks islands.

External characters.—Larger than *arcticus* or *labradorius*; closely similar in color to *arcticus*, but apparently averaging darker, with darker ears; very similar in color also to *labradorius*.

Cranial characters.—Skull distinctly larger in all dimensions than those of *arcticus* and *labradorius*; upper incisors more decurved than in *arcticus*—about as in *labradorius*.

Color.—Summer pelage (July and August): General tone of upperparts smoke gray or pale smoke gray, more or less shaded with hair brown or fuscous, the tips of the hairs dull whitish; head and face similar but more or less washed with pale pinkish buff; ears blackish brown, sometimes with a faint wash of buff, and bordered on posterior margin with white; legs, feet, and tail white; rump usually darker than the back, sometimes deep mouse gray; chin, throat, and lower sides nearly pure smoke gray; rest of underparts white.

Seasonal changes in color.—Four specimens taken on Backs River, April 12 to 26, are

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[1] Mus. Comp. Zool.

[2] Univ. Michigan Mus.

[3] Amer. Mus. Nat. Hist.

in full winter dress, as are two taken at Gray Bay, Coronation Gulf, on September 28. One taken at Cape Kendall on June 2 shows the gray summer coat coming in on the head and back, but the fluffy winter fur persisting on the sides; the ears are nearly all white but black at the bases in front. The type of *andersoni*, taken August 14 at Cape Barrow on Coronation Gulf, is in complete summer gray coat except for a patch of white on the hinder back; another specimen taken at same locality the same day shows the winter fur coming in all over the body and on the ears; and a third, taken August 15, is nearly all white on the body, with the old summer pelage showing in patches but nearly concealed by the longer white hairs.

The summer coat, thus, is worn for about 2 months—from the middle of June to the middle of August.

Measurements in the flesh.—Average of 11 adults from the Coronation Gulf region: Total length, 632.5 (596–678); tail vertebrae, 61 (50–76); hind foot, 158.8 (151–171); ear from notch (dry), 76.2 (70–84).

Weight.—The only recorded weights of this subspecies are those of 3 specimens taken on Backs River, in April, by H. V. Radford; these weighed, respectively, 8, 8.25, and 8.75 pounds, but taken at that season they doubtless were emaciated; it seems probable that animals taken in the fall would weigh 2 to 4 pounds more.

Skull measurements.—Average of 10 adults from the Coronation Gulf region: Greatest length, 100.9 (97–103.5); basilar length, 76 (73.6–80.4); diagonal length of nasals, 41.1 (37.6–42.7); greatest width of nasals, 21.5 (20.2–23.6); depth of rostrum, 23.8 (23.1–24.1); cranial breadth, 35.5 (33.4–37.7); zygomatic breadth, 50.2 (47.7–51.4); maxillary tooth row, 18.8 (18–19.6).

Remarks.—The Barren Grounds hare is the largest of the mainland races of *arcticus* and is exceeded in size only by *monstrabilis* and by *Lepus othus*.

The range of this subspecies does not extend much to the westward of Franklin Bay; Dr. R. M. Anderson, who explored the entire Arctic coast of Mackenzie while on the Stefansson-Anderson Arctic Expedition of 1908–1912, states that on an overland trip in April from near the south end of Liverpool Bay to a point east of the Mackenzie Delta, no signs of hares were seen. The country is all flat, low tundra—unsuited to these hares. A. E. Porsild states, however, that the Eskimos occasionally kill a hare in the hills east of the Reindeer Station at Kittigazuit, on the east side of the Mackenzie Delta, well south of the northern limit of trees.

Intergradation with *labradorius* in Keewatin seems certain, but no specimens are available from any points east of Aylmer and Beechey Lakes until the shore of Hudson Bay is reached. The eastern limits of *andersoni* on the Arctic coast are not known; hares have been reported at Ogden Bay and Montreal Island, but no specimens are at hand from any point east of Coronation Gulf.

Specimens examined.—Total number, 40, as follows:

Franklin: Cambridge Bay, Victoria Island, 1; Cape Kellett, Banks Island, 1 (skull)[1]; Mackenzie Creek, Victoria Island (lat. 68° 45′ N., long. 111° W.), 1 (skull)[1].

Mackenzie: Aylmer Lake (north shore, near Sandhill Bay), 4[2]; Backs River (near Lake Beechey), 3; Bathurst Inlet, 1[1]; Bernard Harbor, Dolphin and Union Strait, 7 (skulls)[1]; Cape Barrow, Coronation Gulf, 5[1]; Cape Kendall, Coronation Gulf, 1[1]; Cape Parry, 1[2]; Coppermine River (Sandstone Rapids), 2 (skulls)[1]; Dismal Lake, 1 (skull)[1]; Fort Anderson, 1 (skull); Fort Rae, Great Slave Lake, 3; Grays Bay, Coronation Gulf (east end), 2[1]; Lake Beechey, Back River, 1 (skin); Lake Hanbury, 1[1]; Langton Bay, 1 (skull)[2]; Mount Barrow, Cape Krusenstern, 1[1]; Liston Island, Dolphin and Union Strait, 1[1]; Port Epworth, Coronation Gulf, 1 (skull)[1].

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[1] Nat. Mus. Canada.

[2] Amer. Mus. Nat. Hist.

Lepus arcticus monstrabilis Nelson

Ellesmere Island Hare

Lepus arcticus monstrabilis Nelson, Proc. Biol. Soc. Washington, vol. 47, p. 85, March 8, 1934. Type from Buchanan Bay, Ellesmere Island; adult male, skin and skull, no. 126169, U. S. Nat. Mus. (Biol. Surv. collection, no. 3923X); collected April 21, 1901, by J. S. Warmbath.

Geographic distribution.—All of Ellesmere and Devon islands and probably Axel Heiberg Island.

External characters.—Size largest of the races of *arcticus*; adults white at all seasons.

Cranial characters.—Skull similar to that of *andersoni*, but averaging larger; premaxillae greatly lengthened; upper incisors longer, much less recurved, and having a narrower sulcus, which is largely filled with dentine; similar also to that of *groenlandicus* but larger, the incisors projecting forward in a similar curve, but the premaxillae longer; much larger than that of *arcticus*, with more projecting upper incisors.

The skulls of very young individuals of *monstrabilis* (and also of *groenlandicus*) have the upper incisors strongly decurved, much as in adults of the more southern races of *arcticus*; as the young approach maturity the incisors gradually assume the prognathous form of the adults.

Color.—Adults with entire pelage white at all seasons, except for small blackish ear tips; young reported to be pale gray at birth, becoming white before the last of July, except for a wash of gray on head and nose, which persists later.

Measurements in the flesh.—Two adult males from type locality: Total length, 609, 605; tail vertebrae, 51, 70; hind foot, 160, 132. Adult female from Devon Island: Total length, 645; tail vertebrae, 80; hind foot, 150; ear, 110.

Weight.—One from Devon Island, taken by Soper, weighed 11 pounds; 2 taken by Capt. Feilden at Cape Sheridan and Lincoln Bay weighed 9.5 and 11 pounds, respectively; J. S. Warmbath, at Cape Sabine, recorded weights of about 12 pounds.

Skull measurements.—Average of 10 adults from vicinity of type locality: Greatest length, 106.8 (103.2–112.7); basilar length, 79.3 (76.3–83.4); diagonal length of nasals, 41.5 (39.5–44.3); greatest width of nasals, 21.1 (20–23); depth of rostrum, 24 (22.2–26.4); cranial breadth, 36.4 (34.8–37.6); zygomatic breadth, 50.7 (48.3–52.3); maxillary tooth row, 18.4 (17.7–19.1).

Remarks.—The Ellesmere Island hare—largest of the races of *Lepus arcticus*—has an extensive range on the Arctic islands, reaching the extreme limit of land, and found even on the ice 20 miles to the north of Grant Land, in latitude 83° 10′ (Feilden, 1877, p. 351).

The single skull examined from the southern part of Devon Island is typical of *monstrabilis* and is so much larger than skulls of *arcticus* from Bylot and Baffin islands that intergradation between these two races seems unlikely. Hares are known to occur on Cornwallis, Melville, and Parry islands, but in the absence of any specimens from those localities, it is uncertain whether the animals are referable to *monstrabilis* or to *andersoni*.

Specimens examined.—Total number, 30, from localities as follows:

Ellesmere Island: Buchanan Bay, 5; Cape Sheridan, 5 (skulls)[1]; Craig Harbor, 5[2]; Grant Land (northeast of), 10 (skulls)[1]; Woodward Bay, 4 (skulls)[1].

Devon Island: Dundas Harbor, 1 (skull)[2].

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[1] Amer. Mus. Nat. Hist.

[2] Nat. Mus. Canada.

Lepus arcticus groenlandicus Rhoads

North Greenland Hare

Lepus groenlandicus Rhoads, Amer. Naturalist, vol. 30, p. 237, March 6, 1896 (author's separates issued February 20, 1896). Type from Robertson Bay, northwestern Greenland; adult, skin and skull, no. 1486, Acad. Nat. Sci. Philadelphia; collected August 2, 1892, by C. E. Hite.

Lepus variabilis var. *glacialis* Winge, Meddelelser om Grönland, vol. 21, pt. 2, p. 375, 1902 (not of Leach).

Boreolepus groenlandicus Barrett-Hamilton, Hist. British Mamm., pt. 12, p. 298, October 1912.

Lepus variabilis hyperboreus Pedersen, Meddelelser om Grönland, vol. 77, p. 363, 1930. Proposed for the hare of eastern Greenland; name preoccupied by *Lepus hyperboreus* Pallas (Zoögraphia Rosso-Asiatica, vol. 1, p. 152, 1831), applied to a species of *Ochotona* of eastern Siberia.

Lepus arcticus persimilis Nelson, Proc. Biol. Soc. Washington, vol. 47, p. 84, March 8, 1934. Type from south side Clavering Island, east Greenland; adult, skin and skull, no. 13461, Acad. Nat. Sci. Philadelphia; collected August 6, 1930, by Harry Whitney.

Geographic distribution.—Coastal belt and adjacent islands of Greenland, from vicinity of Holsteinsborg on the west coast north to the extreme northern tip of Greenland, and on the east coast south to beyond Cape Dalton—approximately 70° latitude.

External characters.—Similar to *monstrabilis*, but somewhat smaller; summer pelage mainly white, with a slight grayish wash on the head and upperparts.

Cranial characters.—Skull similar to that of *monstrabilis*, but averaging smaller; upper incisors slightly less projecting.

Color.—Summer pelage (August): Head and face mainly white, with a wash of either pale smoke gray or pale pinkish buff; anterior surface of ears pale pinkish buff mixed with hair brown; posterior surface white, the tips blackish brown; upperparts white, faintly washed with pale smoke gray; chin, throat, underparts, tail, and legs, white. *Winter pelage:* Pure white except tips of ears. A specimen from Etah, August 11, is pure white except for drab-gray patches on the ears.

Immature specimens in August are mainly white except on the head and ears, which are wood brown; the under fur is pale neutral gray and there is a wash of pale cinnamon-buff in the middle of the back. Pedersen (1930, p. 366) says that at birth the young hares are gray on the upperparts and on the under side of the neck; the ears are lighter on the front side—almost yellowish—and white on the lower side, with black tips; only the belly is white.

Seasonal changes in color.—According to Pedersen (1930, p. 366), the change from winter to summer coat takes place during the latter half of June. Apparently this pelage is carried but a short time, for he says that by the middle of August only pure white adult hares were seen. His observations refer to the hares of east Greenland.

Measurements in the flesh.—Average of 5 males from Ymer Island, east Greenland: Total length, 614 (590–632); tail vertebrae, 64 (50–76); hind foot, 155 (152–160). The hind feet of 7 adults from Clavering Island and vicinity, measured dry, 148 (144–151). Average of 5 adults from Etah and Robertson Bay: Total length, 646 (630–660); hind foot (dry), 143.7 (136–149).

Weight.—A specimen, the largest of 3 taken at Etah by Harry Whitney (1910, p. 34) weighed 12.25 pounds.

Skull measurements.—Average of 10 adults from vicinity of type locality: Greatest length, 104.2 (100.6–107.8); basilar length, 77.8 (74.2–80); diagonal length of nasals, 41 (37.3–44.1); width of nasals at base, 20.9 (19.1–22.3); depth of rostrum, 24 (23.1–25.1);

zygomatic breadth, 49.6 (48.2–51.9); cranial breadth, 34.8 (32.8–36.8); maxillary tooth row, 18.6 (17.4–19.4).

Remarks.—Skulls of *groenlandicus* from the type locality average smaller than those of *monstrabilis* from Ellesmere Island, on the west side of Smith Sound; specimens from the middle west coast of Greenland (67 to 72 degrees latitude) average smaller than those from the vicinity of the type locality, and the upper incisors are more decurved, thus showing intergradation with *porsildi*.

Arctic hares have been recorded from many points on the northern coast of Greenland, even as far as Peary Land, beyond 83 degrees latitude but no specimens are available from that coast north of Smith Sound; on the northeast coast the hares are recorded from many points, south as far as Clavering Island and the region about Scoresby Sound. Manniche (1912, p. 27) mentions their occurrence in Lambert Land, Amdrup Land, and F. E. Hyde Fiord. Pedersen (1930, p. 372) speaks of their abundance on the Liverpool Coast and the adjacent islands, at Cape Greg, and on the west coast of Rathbone Island. South of Scoresby Sound he reports them scarce as far as Cape Dalton.

Nelson separated and named the east Greenland hares on the basis of alleged differences in the size of the skulls and in the curve of the upper incisors; it is evident, however, from a study of his manuscripts that he compared skulls of the east Greenland form with a series of *groenlandicus* from the Disko Island region of west Greenland instead of with a series of topotypes from Robertson Bay in northwest Greenland. Comparison of typical specimens from both coasts shows practically no average difference in the measurements of the skulls of the two series. The auditory bullae in the east coast animals appear slightly larger, but this does not show in measurements and the difference is too slight and inconstant to warrant separation of the form.

Barrett-Hamilton (1911, p. 160) has proposed the generic name *Boreolepus* for the Greenland hare, "based specially on its protruding premaxillary region and large slightly curved upper incisors." Examination of a large series of skulls from the west coast of Greenland clearly demonstrates that there is complete gradation from the projecting incisors of *groenlandicus* to the recurved incisors of *porsildi*. This character, therefore, is of no more than subspecific value.

Specimens examined.—Total number, 64, from localities as follows:

Greenland: Cape Alexander, 2; Clavering Island, 4[1]; Disko Island, 6 (skulls); Etah, 11[2]; Francis Joseph Fiord, 3[1]; North Fiord, 1[1]; Holsteinsborg, 1[3]; Inglefield Gulf, 1 (skull)[4]; Northumberland Island, 15; Nivag, 4 (skulls); Nugsuak Peninsula, 7 (skulls); Olriks Bay, Murchison Sound, 1[3]; Robertson Bay, 3[1]; Smith Sound, 1; Sonntag Bay, 1 (skull)[1]; Tkamiut, 1 (skull); Tsortog Fiord (65° 30′ N.), 1 (skull); Tugnerit (72° 7′ N.), 1 (skull).

Lepus arcticus porsildi Nelson

South Greenland Hare

Lepus glacialis Müller, Vildtet og Jagten i Sydgrönland, p. 359, 1906 (not of Leach, 1819).

Lepus arcticus porsildi Nelson, Proc. Biol. Soc. Washington, vol. 47, p. 83, March 8, 1934. Type from near Julianehaab, Greenland (61° 20′ N. lat.)[5]; skin and skull, no. 248723, U. S. Nat. Mus. (Biological Survey collection); collected September 5, 1926, by O. Hastrup.

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[1] Acad. Nat. Sci. Philadelphia.
[2] Univ. Michigan.
[3] Amer. Mus. Nat. Hist.
[4] Mus. Comp. Zool.
[5] Wrongly given as 60° 20′ in original description.

Geographic distribution.—Extreme southern Greenland, north on the west coast to about 65 degrees latitude; extinct on the east coast.

External characters.—Similar in size to *arcticus*; smaller than *groenlandicus*; summer pelage mainly white.

Cranial characters.—Skull similar to that of *arcticus*, averaging slightly smaller; upper incisors similarly decurved, averaging slenderer, with a narrower sulcus; frontal region with a more prominent bulge at a point just behind the postorbital processes; depressed portion of outer face of zygomatic arch extending farther forward; roots of 4 (rather than 3) of the molariform teeth projecting into the orbit, appearing as a series of rounded protuberances in the maxillary bone. Compared with *groenlandicus* the skull of *porsildi* is distinctly smaller, although the parietal breadth and the zygomatic breadth of the two races average the same; the upper incisors are shorter, slenderer, and strongly decurved.

Color.—Summer pelage (July, August, and early September): Mainly pure white, the back and head sometimes flecked with blackish hairs; anterior outer surface and inside of ears sometimes smoke gray, with a faint buffy wash; posterior surface of ears white, the tips brownish black.

Seasonal changes in pelage.—Müller (1906, p. 360), writing of the hares of south Greenland, says the young are born gray-brown, and they keep this dress until well into July—sometimes longer. During their growth they gradually become lighter and at the end of August they are white, with a slight bluish cast on the legs and flanks and with slate-gray on the back and head. Late in September they are generally pure white, with black ear-tips, sometimes with a faint bluish tint, and by the middle of October they have acquired the shining white winter pelage that is white down to the skin.

Measurements.—External measurements and weights of this race, taken in the flesh, are not available; the hind foot, in 3 specimens measured dry, is 130.8; 131; 132.4.

Skull measurements.—Average of 8 adults from Julianehaab (5) and Neria (3): Greatest length, 98.6 (96.9–100.3); basilar length, 74.1 (73–75.9); diagonal length of nasals, 41 (40–42); width of nasals at base, 21 (20.2–22.7); depth of rostrum, 23.1 (21.3–24.1); zygomatic breadth, 48.3 (47.5–49.7); cranial breadth, 34.5 (33.3–36); maxillary tooth row, 18.4 (17.3–19.6).

Remarks.—In size and general form the south Greenland hare closely resembles typical *arcticus*, but it does not become gray in summer, as do the hares on Baffin Island. It has the most limited range of any member of the group, occurring only in a narrow strip along the west coast of Greenland, a few degrees from the southern tip, and merging northward into *groenlandicus*.

Specimens examined.—Total number, 23, as follows:

Greenland: Julianehaab (vicinity, 61° 20′ N. lat.), 6; 60° 42′ N. latitude, 10 (skulls); Neria (61° 36′ N. lat.), 4 (skulls); Sukkertoppen, 3 (skulls).

Lepus othus Merriam

General characters.—Similar to the mainland races of *Lepus arcticus*, but coloration more brownish (less grayish); upperparts cinnamon-drab or verona brown; upper incisors strongly recurved.

Lepus othus othus Merriam

Alaska Tundra Hare

Lepus timidus arcticus Nelson and True, Rept. Nat. Hist. Coll. Alaska, p. 271, 1887 (not *Lepus arcticus* Ross).

Lepus tschuktschorum Rhoads, Proc. Acad. Nat. Sci. Philadelphia, 1896, p. 371 (not of Nordquist).

Lepus othus Merriam, Proc. Washington Acad. Sci., vol. 2, p. 28, March 14, 1900. Type from St. Michael, Alaska; adult (skull only), no. 15883, U. S. Nat. Mus.; collected February, 1877, by L. M. Turner.

Geographic distribution.—"Tundras of northern and northwestern Alaska, exclusive of the Peninsula and Bristol Bay section. Vertical range from sea level up to over 2,000 feet altitude" (Nelson, 1909). South to the Kuskokwim River region; east to the upper Colville River and possibly farther.

External characters.—Largest of the mainland Arctic hares; color in summer more brownish (less grayish) than in any of the races of *arcticus*.

Cranial characters.—Skull massive; similar in general to that of *andersoni* but averaging larger, and with upper incisors more strongly recurved; rostrum deeper; upper molars heavier. Compared with *monstrabilis*: Skull about the same size, but incisors strongly recurved, rostrum heavier, and upper tooth row longer.

Color.—Summer pelage (Shelton, Alaska, August 23): Nose and sides of face cinnamon-buff; top of head similar, but appearing darker by reason of the subterminal fuscous bands on the hairs showing through; anterior half of outer surface of ears similar to the head; posterior half white, the tips fuscous; general tone of upperparts about cinnamon-drab, the individual hairs pallid neutral gray at base, fuscous subterminally, the tips light pinkish buff or cartridge buff; there also are numerous blackish guard hairs intermixed; front legs white, with a wash of cinnamon-buff on the anterior surface; hind legs white, washed with hair brown; tail white.

An adult female from Teller, Alaska, August 3, is similar, but the underfur is light pinkish cinnamon, the rump is neutral gray, the front legs more strongly washed with cinnamon-buff; the ears extensively marked with blackish brown, and the tail washed with neutral gray. *Winter pelage:* Pure white, except for black tips to the ears.

Seasonal change in color.—There are no specimens available showing the progress of the spring molt. A specimen from Nome, September 15, is still in the brown summer fur, but shows patches of white appearing on the shoulders and rump and on the ears; the legs and feet are pure white.

Measurements in the flesh.—Average of 5 adults: Total length, 624 (565–690); tail vertebrae, 82.5 (65–104); hind foot, 179 (170–189).

Weight.—Two adults from Teller, Alaska, weighed, respectively, 9.5 and 10 pounds. Burt M. McConnell states that several hares killed near Nome in autumn weighed 14 to 16 pounds.

Skull measurements.—Average of 10 adults: Greatest length, 105.3 (101.9–108.7), basilar length, 80.5 (77.5–83.3); diagonal length of nasals, 43.2 (40.3–47.6); greatest width of nasals, 22.4 (21.3–23.8); depth of rostrum, 25.8 (24.7–27); cranial breadth, 36 (34.7–37); zygomatic breadth, 51.5 (49.3–53.2); maxillary tooth row, 20 (19.2–21.1).

Remarks.—The Alaska tundra hare differs from its nearest neighbor, *andersoni*, in its distinctly larger size and in its brownish rather than grayish summer pelage. Furthermore, there is a considerable gap between their ranges; hence it is necessary to give *othus* the rank of a species.

Comparison of *othus* with the Siberian hare (*Lepus tschuktschorum* Nordquist) indicates that the two are closely related. One summer skin and 2 skulls of *tschuktschorum* have been available for comparison. The skin (no. 15278, Mus. Comp. Zool.), from Cape Bolschaja Baranov, Siberia, differs from examples of *othus* in lacking the cinnamon-buff tone of the upperparts; the subterminal portions of the hairs are fuscous and the tips pale buff. The skull of *tschuktschorum*, judging from the two specimens examined, seems to be about the same size as that of *othus*, but the rostrum and nasals are shorter and broader. Nordquist (1883, pp. 86–87), in the original description, gives measurements indicating that the skull of *tschuktschorum* averages considerably larger than that of *othus*. His measurements of the hind foot (170–179 mm.) nearly equal

those of *othus*. Until an adequate series of the Siberian hares is available for comparison, it seems desirable to regard *othus* and *tschuktschorum* as distinct species.

These hares are reported as numerous along the coast of Alaska as far north as Cape Lisburne, but on the north coast from Point Barrow eastward they apparently are absent, though occurring sparingly at a few points back from the coast. Dr. R. M. Anderson, who is very familiar with that region, writes as follows:

"I wintered at Collinson Point in 1913–1914 and made one sheep-hunt in the fall near the head of one branch of the Sadlerochit River and another in the spring to Hula Hula River, and we saw no trace of hares. I also spent the months of October and November, 1908, in the mountains of the Hula Hula, crossing the divide in December and remaining until March, hunting and trapping on the south side of the Endicott Range without seeing any hares."

Charles D. Brower, in a letter to Dr. Nelson, wrote: "Regarding the Arctic hares this far north I would say that in all my experience I have never known them to live on the low tundra anywhere near the coast. In 1884–85, when I wintered at Corwin coal mine, they were fairly abundant in that region and a few were taken inland from Point Lay. During the winter of 1897 I had a hare brought me from inland on the Chipp River. I gave the whole animal to E. A. McIlhenny, who sent it out with his collection. Several times I have had these large hare skins brought in to Barrow by natives wintering up the Colville River, so I take it they must be fairly numerous inland where the ground is high."

Specimens examined.—Total number, 48, from localities as follows:

Alaska: Akiak, 1 (skull); Bethel, 20 (2 skins with skulls; 18 extra skulls); 75 miles below Bethel, 1 (skull); Kotzebue Sound, 1[1]; Kwikluak, Yukon Delta, 2 (skulls); Nome, 2; mountains northwest of Nulato River, 2 (skulls); Shelton, 1[2]; St. Michael, 10 (2 skins with skulls, 8 extra skulls); Teller, 5 (one skin with skull[2]; 4 extra skulls); Yukon River, 3 (skulls; no definite locality).

Lepus othus poadromus Merriam

Alaska Peninsula Hare

Lepus poadromus Merriam, Proc. Washington Acad. Sci., vol. 2, p. 29, March 14, 1900. Type from Stepovak Bay, Alaska Peninsula; adult, skin and skull, no. 98068, U. S. Nat. Mus. (Biol. Surv. collection); collected July 8, 1899, by Charles Palache.

Geographic distribution.—Alaska Peninsula and Bristol Bay district, Alaska.

External characters.—Similar to *Lepus othus othus*, but smaller and richer colored; tail partly gray in summer pelage.

Cranial characters.—Skull similar to that of *othus*, but smaller in all dimensions; about the size of that of *andersoni*, but nasals averaging smaller and upper tooth row longer.

Color.—*Summer pelage* (type, July 8): General tone of upperparts verona brown, with some admixture of white guard hairs (probably remains of winter pelage); nose and sides of face sayal brown; top of head darker (like back); a band of tilleul buff nearly encircles eye; ears like back, but shaded with fuscous and edged with white; front legs wood brown, with small patches of buffy white; hind legs similar, the hind feet mainly white; tail smoke gray, shaded above with fuscous and with some white hairs intermixed; flanks shaded with hair brown; rump shaded with fuscous; chin and throat pale smoke gray; under side of neck smoke gray, shaded with fuscous; belly yellowish white in the center, pale smoke gray on the sides. *Winter pelage:* Entire body pure white, except for small black tips to the ears.

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[1] Acad. Nat. Sci. Philadelphia.

[2] Carnegie Mus.

Seasonal change of color.—The spring molt occurs about the first of June. A specimen from near Pavlof Mountain, taken May 25, is still in the white winter pelage, with three small patches of brown hair appearing—two on the neck and one on the hinder back. O. J. Murie reports seeing two white animals on June 1, and one on June 7 that was grayish in color. A specimen from Sand Point, taken June 9, was in process of acquiring the summer coat; the winter fur is mainly gone from the head and back, but the ears and feet are mostly white and small patches of white fur are seen on the back and sides.

A specimen from Chignik, taken October 23, is in a brownish coat, of a slightly different shade from that of the type (hairs white at the base, then cinnamon-buff, then fuscous, tipped with pale buff); the tail and hind feet are pure white and there is a whitish patch on the nape; the pelage of this specimen appears to be fresh, thus suggesting that possibly some individuals do not become entirely white in winter.

Measurements in the flesh.—One adult from near Pavlof Mountain measured as follows: Total length, 570; tail vertebrae, 65; hind foot, 170; the hind foot of the type measures 164 mm., dry.

Average cranial measurements

	GREATEST LENGTH	BASILAR LENGTH	DIAGONAL LENGTH OF NASALS	WIDTH OF NASALS AT BASE	DEPTH OF ROSTRUM	CRANIAL BREADTH	ZYGOMATIC BREADTH	MAXILLARY TOOTH ROW	NUMBER AVERAGED
Lepus a. arcticus	99	75.2	40.4	20.8	23.5	34.7	48.5	18.1	5
Lepus a. labradorius	95.4	72.2	40.2	20.4	22.2	35.3	48.5	16.7	7
Lepus a. bangsii	98	76	41.9	22	23.2	35.6	48.6	18	7
Lepus a. andersoni	100.9	76	41.1	21.5	23.8	35.5	50.2	18.8	10
Lepus a. monstrabilis	106.8	79.3	41.5	21.1	24	36.4	50.7	18.4	10
Lepus a. groenlandicus	100.7	74.2	39.3	19.1	23.4	33.9	48.2	18	10
Lepus a. porsildi	98.6	74.1	41	21	23.1	34.5	48.3	18.4	8
Lepus othus othus	105.3	80.5	43.2	22.4	25.8	36	51.5	20	10
Lepus othus poadromus	99.7	76.2	39.5	20.7	23.7	35.1	49.9	19.6	10

Weight.—James Oliver, writing from Chignik Bay, says these hares weigh about 9 or 10 pounds.

Skull measurements.—Average of 10 adults: Greatest length, 99.7 (97–101.5); basilar length, 76.2 (73–78.8); diagonal length of nasals, 39.5 (37.3–42.5); greatest width of nasals, 20.7 (19–22.6); depth of rostrum, 23.7 (22.7–24.9); cranial breadth, 35.1 (33.4–37.4); zygomatic breadth, 49.9 (48.1–51.7); maxillary tooth row, 19.6 (18.8–20.8).

Remarks.—The Alaska Peninsula hare is apparently not very common and is particularly difficult to obtain in summer, when in the brown pelage. James Oliver, writing from Chignik Bay in 1910, says "they were plentiful about 12 years ago [1898] but have been decreasing ever since."

Murie states that they live in the dense alder patches and come out in the evening to feed. He offered a good price for summer specimens but although several local hunters tried to get some none was obtained.

Specimens examined.—Total number, 14, from localities as follows:

Alaska: Chignik, 2; Cold Bay, 1 (skull); Kawatna Bay, Shelikof Strait, 1 (skull); Nushagak, 1; Pavlof Mountain (15 miles west), 1; between Portage Bay and Becharof Lake, 6 (skulls); Sand Point, 1; Stepovak Bay, 1.

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MOISTURE AND ITS RELATION TO THE CONE-STORING HABIT OF THE WESTERN PINE SQUIRREL

BY WILLIAM T. SHAW

Late one morning during early November, while staying at a locality known as the old Washington State College camp, on the northwest side of Cedar or Moscow Mountain, Latah County, Idaho, elevation about 4000 feet, my thoughts were concerned with the fact that the Richardson pine squirrel (*Sciurus hudsonicus richardsoni*) is one of the few small mammals to be found abroad during times of rain and fog, especially at mid-day. This is in striking contrast to the habits of the Columbian ground squirrel (*Citellus columbianus columbianus*) of the same region, at this elevation found sparingly in the open spaces of the forest. The latter is a mammal that shuns damp foggy weather, by preference remaining at such times in the dry seclusion of its underground nest. This morning as I left camp the clouds were low and it soon started to rain. The day was cheerless, except for the ground surface which lay sunny-bright with recently-fallen larch needles (*Larix*) and other autumn foliage. With my cane, water was beaten off the pendant shrubbery wherever it arched over the trail leading toward the summit. Few animals were abroad, yet here was the Richardson pine squirrel, apparently disregarding the dampness. Occasionally one would be seen scurrying along a prone log. Little it seemed to mind the wet. The idea of its moisture-tolerating nature was not entirely new to me, for its cloudy-day cheerfulness, and especially its cone-scale piles by old soggy decaying stumps and prone wet logs, so intimately associated with water, long since had suggested to me that here existed an interesting and intimate relationship between this sagacious little rodent and the storing in these damp situations of its winter supply of cones.

Here at camp was very strong evidence of this condition, for while this squirrel so consistently is seen around these damp kitchen middens, yet never has it been my experience to see one enter water from choice, although this phenomenon has been observed and recorded by many writers (Hatt, 1929). Near camp was a very soggy, oozy old spring-head, shaded by an enormous lowland fir (*Abies grandis*). The wet area was abundantly filled with decaying twigs, fallen leaves of alder and forest-crumpled ferns, on top of a watery, rich, black humus soil. Here and there water was seen oozing slowly through the trash, gravitating gently down toward a little stream, 100 yards below,

but with sufficient current to keep parts of the spring open and free from snow during the milder parts of winter.

This was a favorite spot for making observations in connection with this peculiar storing habit. Four years before, from November 16 to 18, 1922, the squirrels had been found abundant about the stores at this place. Then they were heard commonly in the lowland fir grove west of camp, both in morning and evening twilight, and less frequently at mid-day. Piles of fir scales told of their feeding places and the old leaf-matted banks indicated a part of their probable storehouses. At intervals they could be heard through the dense fog, and when the sun came out they were unusually cheerful. Later in the same year, from December 28 to 31, they were seen and heard in this deep canyon, during both twilights and even through the short winter mid-day, for now the sun had but a brief glimpse into this dense grove of lowland fir. Then the squirrels were shelling cones of this tree, which they appeared to be getting from the damp ground and crumbly log piles about the cold spring. Piles of cone scales of considerable size were accumulating upon the snow, beneath projecting objects convenient for perches. It is easy to see why they colonize in this grove of fir trees for not only do they have the moisture conditions favorable for the storing of their food, but the great trees shelter them and their marshy cache-grounds from the heavy snow-fall of this region, much of which remains on the spreading limbs overhead. One, too, had but to look into the lower branches of these trees to observe three squirrel nests, about 20 feet from the ground, apparently made of shredded cedar bark (*Thuja plicata*) fastened against the trunk in the first whorl of branches of one of the largest trees. Whether these nests were occupied at this time was not ascertained. Later, from February 23 to 25, 1923, the squirrels were observed still at this spring, and were digging down to their supplies and shelling the recovered cones on top of the snow or upon nearby projecting snags.

Why the need of moisture for the cones in nature?—Unlike many small rodents these squirrels do not possess cheek pouches and so are not adapted to gleaning small objects from the ground surface. Once the conifer harvest is assigned to the wind for distribution, it largely is gone for the pine squirrels. With this moisture relationship in mind, the above-mentioned spring was visited October 20 to 21 and 27, 1923. Again it was found that here were cones stored in quantities. Half a dozen were taken from the cache and by the next day they had been removed, showing the owners' concern. It occurred to me, after studying the situation, that moisture might be a factor of immediate importance in assisting the squirrel in his harvest. All about at this date were evidences of wind distribution of conifer seeds. The cone cutting by the squirrels, begun in this general locality as early as July 4, while they still were feeding upon the old stored cones, had now been completed, as had been their storing of the season's conifer crop in the boggy springs. On Oc-

tober 27 it was noted that the cone clusters on the tops of the lowland fir had been harvested, and now only the erect shafts and a disorganized scattering of cone scales remained. Everywhere the ground was sprinkled with cone scales and winged seeds in proportionate amounts. Now the wind-harvest and forest seeding was nearly completed, and the resin-covered cones, crowding the tree crowns three months ago, meantime had been scattered to the winds, except for those harvested by the squirrels. It is interesting that Dice (1921) found the cone harvesting beginning two months later for *Sciurus hudsonicus hudsonicus* in central Alaska.

Again, on December 1 and 2, 1923, this camp and spring were visited. The mountains were covered with about six inches of snow, yet the squirrels were quite active and their tracks, scale-piles, and voices commonly were in evidence. The lowland fir cone-caches were examined and a space 10 by 17 inches in the soggy spring bed, through which water was oozing sufficiently to keep the snow melted, was found to contain 20 firm, solid, seed-bearing cones of this tree. This was a rather typical pocket such as is found here and there in the bog. It is probable that the water had risen since the cones were stored, which would make the cache seem wetter than it was at the time it was deposited, earlier in the season. Between two very old stumps, now falling into decay, was a well-beaten squirrel path. It appeared as if one of these old stumps was occupied, as holes emerging from it through the snow were bordered with frost. Perhaps, however, they were used only as caches, in winter at least, as a squirrel twice was observed in the lower branches of the big fir, where the three nests above mentioned were located, almost directly overhead.

That their response to drying might be more closely studied, it was found by careful observation that some of the cones of the lowland fir brought to the laboratory October 21, 1923, and left in the dry air, had crumbled to pieces by November 15. Later, December 1 and 2 of the same year, one of the lowland fir cones was brought home for further tests, and although perfectly tight, firm, and resin-smeared when taken from the icy spring water, it began to open when exposed to the warm dry air of the laboratory, and by December 11 had its scales one-third expanded, the warping beginning at the base of the cone. The need of moisture in preventing disintegration of cones also has been noted by Grinnell and Storer (1924). A related idea was expressed by Cram (1924).

Some time later, from October 12 to 16, 1926, a similar observation was made, when it was found that the Richardson pine squirrel was the most conspicuous mammal on the mountain, probably due to the abundant crop of cones during that autumn, and was heard rather constantly. By then nearly all the lowland fir seeds were scattered, and the tree crowns sharply bristled with central cone shafts covered with a wreck of cone scales. On the ground, scales and seeds were scattered profusely. Here, too, the Douglas

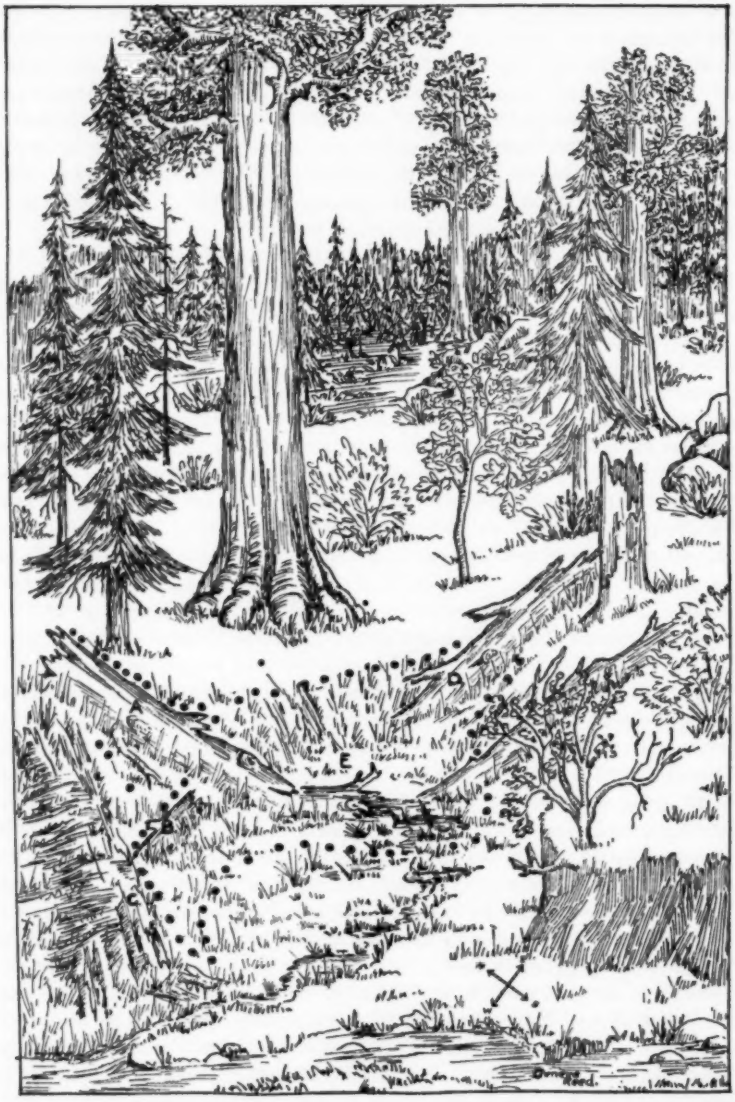

FIG. 1. A sketch showing the cache area of a California pine squirrel at McKinley Grove. In the left center is a giant sequoia. It is from this tree that cones are harvested to be stored in the spring-head area (enclosed in heavy dots). On November 29, 1935, 2479 sequoia cones were found stored in this moist tract. Drawing by Geneva Reed, from measurements and data by Ellen Claybaugh, Dorothy Thompson, Frederick Clark, and William T. Shaw.

fir (*Pseudotsuga taxifolia*), its pendant cones still hanging to the upper branches, also had recently liberated its seeds by opening out its scales and allowing them to sift down into the air.

These observations in the Idaho mountains suggested the necessity of further studies, which, however, were to be considerably deferred as to time and extended as to locality.

Testing cones in relation to moisture.—Our next field for observation was in the Sierra Nevada of California, in the McKinley Grove of Big Trees, elevation 6500 feet, Fresno County. This is in the home range of the California pine squirrel (*Sciurus douglasii albolimbatus*) (fig. 3). Here from our blankets, in the dim light of an early October morning, we watched one of these little harvesters high among the billowy top branches of a giant sequoia (*Sequoia gigantea*), already flooded in cool morning sunlight, industriously dropping cones of this tree. At the immediate base of the tree, in a little fire-gnawed recess beside one of the massive roots and upon the moist earth, a squirrel already had packed away a small cache of sequoia cones.

Nearby was a cold, oozy spring leading down to a little stream. It was very suggestive of the similar situation in Idaho, except, of course, for the surrounding forest trees and wrack of vegetation in the bog itself. Close investigation in one of the little pools revealed a cache of cones of the white fir (*Abies concolor*) (fig. 4). Four of the six cones of this cache were very wet and two of them were entirely submerged. The cone in the foreground was floating in quite a stream of cold running water, coming from a partly clogged spring 15 or 20 feet up the hill side. This was on October 13, at which time the cones were firm and tight, and they were taken to my home in wet paper. On October 17, two of them were exposed to the sun and dry air, where they at once began to exhibit signs of opening and breaking down. On October 24, 1934, the two, together with the other four, which in the meantime had been kept in tap water, were photographed. One of the two exposed to the air was completely opened out, by its own effort, as it had not been touched with the hand, but lay as it had dried. The four that had been kept in water still were tightly closed. In the lower left foreground of the same picture was placed another *Abies concolor* cone, which for 2 years had been kept in plain tap water in the laboratory at ordinary room temperatures, and still was tightly closed. Two of the four closed cones, in the upper left corner of the illustration, had been partly hulled by squirrels, and the remaining parts cached for a future meal. The central cone shaft of the open cone clearly is shown as also are the abundant seeds, still undisturbed (fig. 5).

On October 25, 1934, two cones, one of white fir and the other of silver pine (*Pinus monticola*) (the former taken at McKinley Grove, and the latter at Kaiser Pass, elevation 9300, Fresno County, California, on October 15, 1932) were taken from the jar of ordinary tap water in which they had been kept at room temperature for the intervening 2 years. They now were placed in

the open air of the laboratory. On October 27, the white fir cone began to open, and 8 days later, November 2, both pine and fir cones were active in their response to drying. Then they, together with one of the silver pine cones which had been left in the water, were photographed with results shown in figure 6. A year later, October 4, 1935, one of the silver pine cones, now having been 3 years in tap water, was removed to dry air. By October 11, it was more than half open, and the next day, when it was almost fully open and beginning to lose its seeds, it was returned to the water, when it soon began to tighten and by the next day again was quite closed.

Curiosity as to the condition of the seeds after this long interval led to their examination. At the end of 2 years they still were found to be in good condition, although they tasted more bitter than fresh seeds. They seemed to be somewhat shrunken and in the white fir the pitch associated with them was quite concentrated. At the end of 3 years' submersion, seeds of the silver pine were examined and even yet were discovered to be of good quality and of pleasant taste. An occasional hull, however, was empty.

This interesting and natural response of cones to water must be of great value to the pine squirrels in storing their harvest, and later in enabling them to survive adverse conditions, such as years of cone crop failure.

Curiously enough, this method of cone storing in moisture is in direct contrast to the drying methods used by such rodents as the kangaroo rat (*Dipodomys*), the cony (*Ochotona*) and the mountain beaver (*Aplodontia*) (Scheffer 1929), but is somewhat suggestive of the storing habits of the true beaver (*Castor*).

Range of practice.—That this method of storing the conifer harvest is widely used by these squirrels has been suggested to the writer over a long period of time and a rather wide geographic distribution, covering a considerable part of western North America. The custom, viewed specifically, shows an expected similarity throughout the range of the genus, as has become apparent during the present investigations. The following records illustrate their activity in widely different regions.

California pine squirrel (*Sciurus douglasii albolimbatus*).—In addition to the comments already made in this paper, it may be said that the cone-cutting habit of this squirrel also was noted somewhat farther south, at Sequoia National Park, California. Indeed, the habit of cone-cutting by squirrels is very general, being coincident with conifer forests in North America. It is mentioned by Bailey (1931) in New Mexico, and by Klugh (1927) in New Brunswick.

On October 18 and 19, 1935, the McKinley Grove of Big Trees again was visited and cone-storing activities such as had been observed on former years were found, in the case of both the white fir and the giant sequoia (fig. 7). The lower, moister spring banks were abundantly pitted with pockets filled with cones, and nearby logs were covered with cone scales and cores of white

FIG. 2 FIG. 3

FIG. 2. A northern pine squirrel (*Sciurus h. hudsonicus*) (left) beside a cluster of white spruce (*Picea glauca*) cones. From a posed specimen taken at Bright Sands Lake, Saskatchewan, August 19, 1933. FIG. 3. A female California pine squirrel (*Sciurus d. albolimbatus*) (right). From a posed specimen taken at Huntington Lake, Fresno County, California, October 12, 1930.

Fig. 5

Fig. 7

Fig. 4

Fig. 6

fir. It also was noted that the scales of the giant sequoia cones were not nipped off of the core as were the white fir, but that merely their tips were nibbled into sufficiently to enable the squirrel to reach the seed, which is small, and strange to say, resembles the common parsnip in size and shape.

Again, finding it convenient to visit McKinley Grove on November 29, 1935, we soon observed that continued progress in storing cones had been made since our investigations of October 19, especially those of the sequoia. Provision had been made for making a more searching inquiry into the extent of the operations previously noted. Measurements of the extent of the cache, and a cone count, were to be undertaken. The area was to be charted as shown in figure 1. Results obtained abundantly confirmed the belief that moisture was an intimate accessory to cone storing. For convenience and clearness of expression the tract of cone deposits was divided into areas, A, B, C, D, and E, as shown in this figure.

The first area examined lay on the east side of the white fir log, A, on the shady side in the afternoon. Here, extending for 27 feet in a little depression parallel with the log, but well clear of it and not under it, were 33 caches containing in all 211 sequoia cones, averaging 6.3 cones to the cache, the smallest number being 1 and the largest 20. This area was the highest, driest and farthest from the spring, except for one isolated locality in which a cache of 25 cones had been packed into a shaded cavity in the base of the great tree itself. This tract was favorable for storage, owing primarily to the shade cast by the log and the depressed nature of the ground, involving better retention of moisture. All of these caches, except one which utilized a small decayed stump standing 10 feet east, were in the broad belt shaded from the low winter sun by the log.

In contrast to this, on the west side of the log, exposed to the afternoon rays, were 8 caches of sequoia cones, one of them within the shade of a large stick. These also were small caches containing 28 sequoia cones, averaging 3.5 cones, the smallest 1 and the largest 11, the latter being under the shade of the stick.

Between this log, A, and the huge, greatly decayed white fir log, C, and

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FIG. 4. Upper left. Cache of cones of white fir (*Abies concolor*) in a store of the California pine squirrel. Two of the 6 cones are entirely submerged, in a very wet situation. McKinley Grove, elevation 6500 feet, Fresno County, California. FIG. 5. Upper right. Cones from cache shown in fig. 4. The 2 on the right have been exposed to sun and air for 7 days; the 4 in upper left meanwhile were kept in cold water. The cone in lower left corner is one that was kept continuously in cold water at room temperature for 2 years, yet it still contains edible seeds. FIG. 6. Lower left. The left cone is of silver pine, the right of white fir. Both have been kept in water for 2 years. Photographed after removal from water for 8 days, together with a silver pine cone directly from the water. FIG. 7. Lower right. Cache of sequoia cones in moist bank of spring. The right hand deposit contains 12 tight, green cones. Below the left group is an old cone of former years that has liberated its seeds.

lying directly northwest of the spring, was a smaller log, B, about 6 feet long and greatly decayed. Here, buried in the debris, were three caches with 5, 8 and 6 sequoia cones each.

Buried in the moist earth between log C and the spring were 18 deposits, containing in all 145 cones, averaging 8 cones to the cache, the smallest being 1 and the largest 27. Here, in addition, were 5 white fir cone-caches, the only ones found in the entire area, their scarcity probably being due to a light cone crop of this species.

South of log D were found 22 caches, containing 191 sequoia cones, averaging 8.6 cones to the cache, the smallest being 1 and the largest 34. In the case of the latter, only one cone was visible on the surface. Here also, one cache consisted of cones packed in a vertical hollow knot projecting from the log.

The largest cache of all, E, was centrally placed in the head of the spring. Most of the cones were confluent, and in places were piled one on top of another, although some separate caches were found in the rising ground of the upper left bank. In all there were 1860 cones packed in this area, making a total of 2479 sequoia cones garnered by these squirrels. These cones themselves are small, measuring roughly only 1.5 by 2 inches, as compared to a white fir cone, 1.5 by 4 inches. Whether or not this was the work of one animal could not be ascertained.

In all of these deposits most of the cones were firmly packed and well protected against drying, only the upper layers being exposed to the air, which at this season was abundantly laden with cool moisture.

As though to conserve their stores, the squirrels, in the interval between October 19 and November 29, apparently had been feeding upon the cones in the crown of the great tree, as the ground immediately below now was strewn with nibbled, seedless cones, scattered irregularly over the surface.

Richardson pine squirrel (*Sciurus hudsonicus richardsoni*).—This subspecies also was noted to be using stored cones at Felton's Mill, Latah County, Idaho, elevation about 2600 feet, at a point about 5 miles south of the summit of Cedar Mountain. Here a place was found, on an otherwise dry hill slope in the timber, where there was a moist springy spot. About this area the ground was honeycombed with holes and strewn with scales from cones of Douglas fir, lowland fir and yellow pine (*Pinus ponderosa*). They had been using *stored* cones to this date and were just now, July 4, beginning to feed upon new, green cones. Another wet cache area was found at Wenatchee Ranger Station, Columbia County, Washington, elevation 5500 feet. So evident, in southeastern Washington and adjacent Idaho, was the habit of this subspecies of storing cones in moist places that the matter had been called to my attention by Mrs. Carl S. English, Jr. and Dr. F. L. Picket of the Washington State College.

Cascade pine squirrel (*Sciurus douglasii cascadensis*).—The Cascade pine

squirrel was noted working upon cones at Skyline Ridge, Mount Baker, Whatcom County, Washington, at an elevation of 6000 feet. From July 15 to 20, 1928, it was observed that they were feeding upon cones of the subalpine fir (*Abies lasiocarpa*), which apparently had been stored in quantities in an old crumbling log. Here the squirrels had congregated for some time, probably since the previous year, as was indicated by the quantities of cone scales lying about.

Streator pine squirrel (*Sciurus hudsonicus streatori*).—Hollister (1912) substantiated the idea of the use of moisture in connection with the store, when discussing *Sciurus hudsonicus hudsonicus* and the Streator pine squirrel in the Mount Robson region of British Columbia. He said that "In the muskegs we found numerous caches of spruce and fir cones which the animals had laid away for winter use."

Northern pine squirrel (*Sciurus hudsonicus hudsonicus*).—Observations made August 26, 1928, upon this species were conducted in central-western Saskatchewan, Canada, at a point about 75 miles north of North Battleford, on the east shore of Turtle Lake, Township 54, Range 18. Here the situation was unique in comparison to the more southern habitats mentioned above. The area locally was called the jack pine region. It was a park-like tract of jack pine (*Pinus banksiana*), together with trembling aspen (*Populus tremuloides*) and here and there a willow bush (*Salix*). The dry sandy soil of the treeless spaces was thickly covered with low-bush cranberry and blueberries. We had not been in this area for long when the familiar voice of the squirrel was heard. This mammal soon became the subject of some most interesting observations. Jack pine cones, which they had been harvesting and storing, seemed to be binding them to the locality. One squirrel observed, was found living near an old rubbish heap on the ground. In a nearby tree, close to the trunk, was a tree-nest about 8 inches in diameter, resembling a wasp's nest in shape. When too closely pressed the squirrel passed nimbly from tree to tree, through the branches, and then suddenly, at a favorable moment, descended to the ground and escaped in the old brush heap. Its retreat was covered with jack pine branches and was quite packed in with old cones, cone scales, and dried grass. Many paths led to it through the dry grass of the immediate locality. On investigation, the old brush pile was found to be irregularly interlaced with burrows. Two large new nests of dry dead grass and a little old newspaper were found. They were circular and about 6 to 8 inches in diameter, and one of them was sunken 3 or 4 inches into the ground. Some of the burrows led deeper into the soil, resembling those of ground squirrels. Persons familiar with the locality said that there were no ground squirrels there, which would lead one to believe that in the absence of large timber, *Sciurus* had adapted itself in part to a subterranean habitat. The trees of the immediate vicinity were small, seldom more than a foot to a foot and a half in diameter, and rarely hollow. Thus

it would not be surprising if the animals are obliged to live in the ground, at least during the winter. Seton (1929, p. 121) spoke of *Sciurus hudsonicus* as "the only true squirrel in Eastern Canada that makes and harbours in holes under ground." Murie (1927) also commented at length upon the ground habitations of *Sciurus hudsonicus*. Further investigation revealed cone-caches in which solidly-packed stores of new and old cones were found, sunken into the earth to a depth of 6 to 8 inches, buried in heaps of old decayed scales and central shafts of jack pine cones, suggesting a very old cache. This spot was not near water, but the cones stored in the ground at this date would soon become moist with August and September rains.

Not far distant, in a rather swampy stand of white spruce (*Picea glauca*) on the east side of this lake, was a cache of spruce cones in a hole under moss and grass tussocks. Here the cones were found not only singly, but in clusters comprising the entire tip of a branch. They measured from one inch to one and three-quarters inches in length.

Again, from August 19 to 20, 1933, at Bright Sands Lake, a few miles west of Turtle Lake, Saskatchewan, were found abundant signs of squirrel work. This was in a fairly dense stand of white spruce, bordering a swampy margin of the lake. The ground about was strewn with freshly cut cones. The squirrels were common and had extensive caching grounds alongside the marshy land at points near the water level of the swamp, yet none was observed on the higher, drier shores of the lake.

An interesting observation was noted here on August 19, 1934. One of the squirrels was seen in the top of a white spruce, busily employed in cutting its harvest. The rapidity with which it worked was astonishing. Twice it was timed with the watch and was seen to cut and drop 28 and 29 cones each, in two intervals of one minute each. It would nip a cone free, give its head a jerk backward and sidewise, and thus flip the cone free of the branches. Instantly it would nip another cone from the densely-crowded cluster, to repeat the same performance. A similar observation was made by Dice (1921) in the interior of Alaska.

In all these observations, it has been my experience that the squirrels do not dig fresh holes each year for the accommodation of the cones to be cached, but utilize depressions and holes already in existence; nor do they attempt to cover the cones after depositing them. The smaller caches usually are completed when they have been filled to the ground level. Covering would be disadvantageous at the time of retrieving the cones, when they are held down by frost and snow. On the other hand it is noticeable that the outer rims of the burrows and caches are very neatly moss- or sod-grown, as though but little disturbed from year to year.

Indeed, the pine squirrels are very resourceful and provident, as is shown in the great variety of ways in which they store their widely different kinds of food throughout their range. That moisture is an important factor in the

preservation and care of their conifer harvest seems evident, for not only is it necessary for the cones to be tightened by moisture, but they must be kept so during a long period.

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AN ECOLOGICAL STUDY OF THE MOLE[1]

BY A. V. ARLTON

Moles have been studied for centuries and the literature on the subject is extensive. In Europe early investigators were comparatively few, and therefore many of the writings were compilations, and several writers were influenced by sentimentalism or even superstition. Some of the early American writers borrowed from the European literature and applied the information to American moles. Accordingly, some of the literature on the American species contains material on *Talpa europaea*, which is not applicable.

Among the European writers on the natural history of moles have been Brehm (1890), Vogt and Specht (1888), Flower and Lydekker (1891), and Beddard (1902). Giebel's (1858) writings are general. Retzius (1881) wrote on the sense of hearing, Ritter (1899) on the eyes, and Adams (1903) on mole hills.

In America, Hornaday (1904) and Seton (1908) wrote on the natural history of the mole. Rafinesque (1832), Billings (1837), True (1896), Merriam (1884), and Scheffer (1910) wrote on moles in general. Slonaker (1902) did valuable work on the eye of the mole. Hisaw (1923) has made observations on the feeding and burrowing habits of the animal. Chapman (1919), Hisaw and Zilley (1927) studied the skeleton.

[1]Studies from the Zoölogical Laboratory, University of Nebraska, No. 187.

The chief object of this investigation was to study the ecology of moles. The work was begun in the eastern part of Iowa and, after some interruption, continued in the vicinity of Lincoln, Nebraska.

The writer desires to express his acknowledgment to Doctors R. H. Wolcott and I. H. Blake for their helpful criticisms and suggestions. He also is indebted to Oska Loos, on whose farms moles were studied.

HABITAT

Physical Nature of Soil.—Moles do not favor loose and sandy soil for tunneling unless there be moisture and an abundance of food to compensate for the inconvenience of digging. Neither gravel nor stony soils usually are desirable, but the writer saw a tunnel on a small stony plateau in the School of Mines Canyon in the Bad Lands of South Dakota. The soil seemed most undesirable for tunneling. On the Great Plains, moles are found only in isolated places, apparently because of the prevailingly dry and hard soil. Northeast of Iowa City, Iowa, the soil is loess, which is excellent for tunneling. Wooded areas seem to be the preferred places for moles wherever these were studied, but the animals also are found elsewhere. The optimum habitat is one having soft soil with humus, moisture, and food. Soils that are suitable for earthworms usually are suitable for moles.

Slope.—The sides of hills are chosen in preference to the tops, and the most desirable location on some hillsides seems to be three-fourths of the distance from the foot. The reason for this fact is not known with certainty. It is not due to differences in the alkalinity of the soil at higher or lower levels of the hills, for a chemical test showed that one foot below the surface there was no perceptible difference over any part of the hills. The position of the burrow does not seem always to depend upon the moisture content of the soil, for tunnels which run up and down hill may be extended daily by excavation at both extremities, apparently without preference. From numerous observations, both in Iowa and Nebraska, it appears evident that moles are rather reluctant to change one location for another when once they have become established. After the period of drought at Lincoln, Nebraska, between July 11 and 20, 1930, they decreased their activities on the uplands and tunneled mostly on the lowlands, but returned occasionally to their drier tunnels.

Drainage.—Flood plains frequently are occupied by moles. When such plains are not subject to annual floods, the animals come from higher ground, and in a few years may become comparatively numerous. The soil often is suitable in texture and structure, and often contains desirable kinds of food; even quite sandy flood plains may be occupied, if earthworms abound. When floods occur a large number of moles are drowned. Perhaps this explains the observed scarcity of moles in areas contiguous to flood plains.

Moisture.—With respect to the moisture content of soils, moles seem to exercise considerable latitude in their choice. This has been observed many times in the field, and has been verified by experiments in the laboratory. Two captive moles were kept in separate boxes of sufficient size to contain 3 compartments, each measuring 15 by 25 cm., and an alley 12 cm. wide. The compartments were separated by partitions 5 cm. high and the ends facing the alley were of the same height. This gave the mole opportunity to pass easily from one compartment to the other or to enter any one of them from the alley. In one compartment was placed dry soil, and in another saturated soil. The third compartment contained soil with an intermediate amount of moisture. One mole tunneled through the soil of all the compartments, but finally chose the intermediate one. It brushed aside the soil and remained in a corner of this compartment during periods of inactivity even after the soils had been interchanged. The other

mole did not select any of the compartments, but rested in a corner and on the bare floor of the alley. In an experimental room in which 4 cm. of soil was spread upon the floor, the moles did not appear to make any distinction in their choice of soils, whether moist or dry. In nature moles occupy tunnels in dry, and occasionally in wet soils; but new tunnels are not usually constructed in dry soils. On April 23, 1930, 13 areas examined as to the water content of the soil ranged from 14.4 per cent under bushes in open woods to 48.7 per cent in a woodland ravine. In the latter situation there were 113 earthworms per square meter of soil in the upper first 10 cm., and in the former there were but 3. The soil represented by soil sample no. 6 had 29 per cent of moisture and 3 worms per square meter, and soil no. 7 had 17.2 per cent moisture and 3 worms per square meter; but both of these soils were undesirable for moles because of hardness consequent upon loss of moisture. Although soil sample no. 5 had 25 per cent moisture it was not inhabited by moles, probably because of its hardness and the scarcity of worms near the surface. Soils nos. 6 and 7 had 29.9 and 30.2 per cent moisture respectively, and moles were present because the soil was soft enough to permit tunneling. The moles left the areas represented by the soils nos. 1, 2, 3, 4, and 5, when the areas became hard and dry, and the worms were too deep in the soil.

Temperature.—The soil temperature in a shaded corner of an upland garden from April 7 to July 21 showed a maximum variation from 15.6 to 27.8 degrees Centigrade, a minimum from 2.8 to 24.4, and an average from 11.2 to 25.7 degrees. Moles made frequent visits to the garden during the time indicated, but deserted their tunnels about July 15. There were several factors that made the garden tunnels untenable, including high temperatures, dryness and hardness of soil, and a scarcity of worms.

In an upland open woods, moles used their tunnels during May, June, and a part of July. During that time the maximum temperature of the air varied from 26.7 to 43.3 degrees Centigrade, the minimum from 4.4 to 13.3, and the average from 16.3 to 27.9 degrees. The soil temperature was more constant. The maximum varied from 13.5 to 21.9, the minimum from 9.4 to 18.3, and the average from 8.7 to 19.7 degrees.

COMMUNITY RELATIONS

Associated Invertebrates.—In order to discover the kind and the number of invertebrates present in the soil in proximity to mole tunnels, representative areas one meter square were spaded to a depth of 10 cm. There was a scarcity of insects in the soil, but a few on top. Ants were found in more than 50 per cent of the areas examined. White grubs were found in two areas and earthworms in all. In area no. 1 there was one worm; in nos. 6, 7, and 9, three worms; in nos. 3, 4, and 5, six worms; in no. 8, eleven worms; in no. 2, twenty-one worms; in no. 12, thirty-two worms; in no. 10, eighty-nine worms; in no. 13, one hundred thirteen worms; and in no. 11, two hundred fifty-six worms. All the areas were contiguous to mole burrows except nos. 6 and 9, which were a little distance from the woods, where the soil was hard.

On July 14 the soil in the 7 locations referred to was examined for invertebrates. No insects were found and the earthworms were deep. The moles left the regions and went to lower ground. Areas nos. 1, 2, 3, 4, and 5 were deserted on July 14, but moles were still in areas nos. 6 and 7, which were moist and soft.

Associated Vertebrates.—Other small animals, such as ground squirrels, pine mice, and shrews, are said to occupy mole tunnels. During the present observations, ground squirrels were seen to occupy abandoned mole tunnels. To ascertain whether other species made use of mole tunnels, a number of mouse traps were set. A depression was dug across the mole tunnel, and the traps were set at the bottom. Some of the traps were baited; others were not. The depressions were covered with old boards or shingles, and then covered with soil. Although the traps were out several weeks, only one mouse (*Mus musculus*) was caught. It is not possible to draw conclusions from so few observa-

tions, but it may be said with safety that in the locality studied near Lincoln, Nebraska, very few, if any, mammals occupy the same tunnels with moles, although at times pocket gophers may occupy the same area. When pocket gophers build mounds across the path of mole tunnels, the moles may tunnel around or through the mounds.

The attitude of moles toward other vertebrates is not well known. During the present experiments a young mouse was placed in a box with a mole. The latter pounced upon the mouse and endeavored to bite it, but did not seem able to do so. When the mouse tried to defend itself, the mole was frightened away. Another mole showed no inclination to disturb a mouse.

Enemies.—The enemies of the American moles are most of the carnivores, and some of the predaceous birds. Of the latter may be mentioned the red-tailed hawk, red-shouldered hawk, broad-winged hawk, and barred owl. Man destroys a large number of moles yearly. As yet comparatively few moles are captured in America for their fur.

Parasites.—Moles have a few parasites, either internal or external. The latter are most numerous during the summer months. *Leptinus testaceus* (Müller) is a small, uncommon beetle. *Euhaematopinus abnormis* (Osborn), a louse, is more numerous than any other parasite. A species of flea, *Ctenophthalmus pseudagyrtes* Baker, also occurs on moles; 14 were found on one mole. At times the ectoparasites appear to be annoying, for an animal may stop feeding in order to scratch itself, run frantically about, or rub itself against some object.

Of the internal parasites, specimens of the genera *Filaria* and *Spiroptera* have been found in abundance in the intestinal tract of moles. Scheffer (1913) examined the stomachs of 100 moles and found that 28 were infested with parasitic threadworms. No parasites were found in the moles examined in the laboratory at Lincoln, Nebraska.

BEHAVIOR

Tunneling.—The tunnels were studied in the field. Surface tunnels could be seen without difficulty, but the deep ones required excavation with a trowel or spade. A heavy wire 60 cm. in length served as a probe to discover the direction of the tunnels. Depths were measured with the trowel, and distances were stepped off or measured with the spade. Drawings of tunnels were made by the use of base lines and coördinates. Frequently, lime was sprinkled on surface tunnels and mounds to facilitate photographing them.

It has been believed that moles dig with the fore feet and raise the dirt with the head (Merriam, 1884), back and shoulders (Herrick, 1892). Hornaday (1904) stated that the mole uses the nose in boring through the soil. Hisaw (1923) observed that moles constructed surface tunnels by lateral motions of the fore feet. The animal twists its body, while one front foot rests against the bottom of the tunnel and the other pushes the soil upward.

The writer has observed that when a captured mole is placed upon the ground, it seeks immediately for a place to dig. The fore feet are placed close to the snout and the earth is pushed aside. The snout becomes active, not in boring or in shoving the earth aside, but in discovering a suitable spot to place the fore feet for the next side-stroke. In a few seconds the mole is half buried. Then the animal twists the anterior half of its body, turning on its side, and pushes the soil upward with its fore feet. In this way are made the conspicuous ridges commonly called surface tunnels. Moles were trapped in the twisted position. These observations indicate that the mole does not raise the soil upward with the head, shoulders, or back, but with the fore feet. A mole seen constructing a surface tunnel in a corn field pushed the soil upward, not suddenly with a single movement, but with several, alternately using the right and left

fore feet. The animal apparently rested at intervals, or stopped to eat some morsel. At times its snuffling could be heard. Now and then it retreated a few decimeters and pushed up the soil more here and there. At no time did the roof of the tunnel cave in, nor did the animal expose itself. The movements were inferred from the manner in which the soil was elevated.

When a mole constructs surface tunnels it seems to know its situation in respect to the surface. Although the tunnel may be over 90 meters in length, it consistently follows the same depth below the surface of the ground. In the case of surface tunnels observed on the steep bank of a stream, the soil was so carefully pushed out that scarcely any fell to the water below. The displaced soil formed a bulge over the side of the tunnel. Had the soil been pushed a little more, it would have fallen and left the tunnel exposed.

Deep tunnels are constructed without surface ridges, but their situation may be indicated by small mounds on the surface. At times there may be no sign of the presence of such tunnels, as when the soil is stored in abandoned tunnels (Hisaw, 1923). After uncovering a large number of deep tunnels I believe that this method of storing soil is very unusual.

Moles spend much time and labor in constructing the deep tunnels. Hisaw (1923), by placing moles in a narrow box with glass sides and bottom, was able to observe how they dig deep tunnels. The earth is loosened by clawing with the fore feet and is thrown beneath the body. Periodically the excavated earth is kicked back with the hindfeet. At times the animal turns in its burrow and with the fore feet shoves the dirt through the tunnel and then to the surface. I have seen captive moles shove soil about in this manner. The animal turns the anterior portion of its body to the side while the palm of one front foot shoves the soil ahead. The other front foot is used as a brace, and together with the hind feet propels the animal and its load.

The depth of the deep tunnels varies from 2.5 to 60 cm., rarely more. From 10 to 35.5 cm. is the average. As a rule the deepest places in the tunnel are not directly under the mounds, but between them. The process of clawing the soil and bringing it to the surface is repeated until the tunnel has reached the customary depth. The tunnel then takes an upward trend, usually at an easy inclination, until it reaches the surface, where a new mound is started. In time, there may be 20 mounds for a single tunnel. They may be close together or as much as 3 meters apart, and may contain from a mere handful to as much as 13 liters of soil. When the mounds become large, the mole may pierce them, pushing the soil to the edge. On the hillsides the deeper sections, especially in the branched tunnels, more often point up hill than down, because in the latter case the soil has to be brought to the surface up an incline. Furthermore, the deeper portions that point down hill are more apt to fill with water or soil during rainy weather than those headed up hill.

It is claimed that moles are able to construct deep tunnels through the soil by pressing it aside (Cory, 1912). I have found no deep, moundless tunnel. When a mole in digging surface tunnels encounters obstacles such as cement walks, steps, or curbs, it brings the soil to the surface. It seems evident, therefore, that moles cannot dig deeply without bringing the soil to the surface.

The position of tunnels with respect to the banks of streams and gullies is variable. Besides passing around posts the tunnel may run spirally downward around them. In places where moles abound, tunnels usually run under logs or fallen trees that lie on the surface.

Mole tunnels vary in length. Frequently they are limited in extent, measuring less than a meter. In such instances the animals evidently began excavating and then abandoned the tunnel before completing it. One surface tunnel measured 91 meters in length, and one branched tunnel system covered an area of about 3,540 square meters

(fig. 2). Tunnels along fence lines may reach 1000 or more meters in length. They often serve as lines of communication between a large number of individual tunnels. Some tunnels seem to remain the same length from year to year. Perhaps a sufficient quantity of insects and worms enter such tunnels to supply the mole with food and make extension unnecessary, or these tunnels may serve as highways between the nest and the foraging grounds of the animal.

Activities.—The writer observed a mole constructing a surface tunnel in a cornfield. The soil was somewhat packed due to excessive rains. In 26 minutes the mole dug a tunnel 1.67 meters in length, the equivalent of 3.91 meters per hour.

Moles are stronger than their size indicates. When one constructs a surface tunnel in sod, the roots of the plants are broken with a crackling sound and the soil is raised

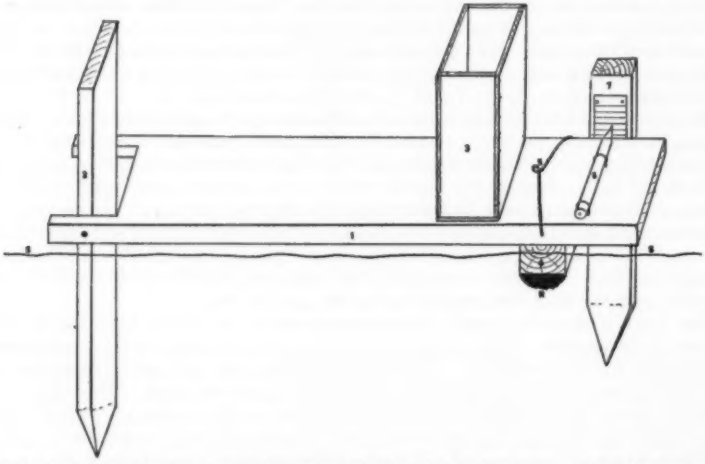

FIG. 1. Apparatus for measuring strength of moles in the field. Lever 1 is parallel to the surface of the ground, S; 2, a stake on which 1 hinges; 3, a box for weights; 4, a block of wood resting over a trampled portion of a surface tunnel, R; 5, a wire loop to which a spring balance may be fastened to measure the strength necessary to lift 1 and 3; 6, a pencil resting against scale on stake 7. When a mole repairs its tunnel it pushes up block 4 and lever 1. The weights lifted designate the strength of the mole.

with considerable force. To measure the strength of moles, two kinds of apparatus were employed. One was used in the field and was placed on the mole tunnel (fig. 1). In order to pass through the tunnel the mole was obliged to lift the weight of the apparatus. The maximum weight lifted was in excess of 3 kilograms. In using the other apparatus (fig. 3) it was necessary to place a live mole in box no. 8. When the mole attempted to escape through the opening between the stationary piece 7 and sliding door 5, the strength required was indicated on the spring balance attached to the sliding door. A mole weighing 120 grams was caught in a mole trap; it was severely injured in the thoracic region, but moved the sliding door against a counter force of the balance, equal to 26.4 times its own weight. Another mole moved a mass 32 times its own weight. A man weighing 150 pounds would be obliged to lift, in proportion, 4800 pounds.

The appearance of a mole might give the impression that its neck is too short and the body too rigid to permit the animal to turn in its burrow. Upon close observation, however, it may be noticed that the head is capable of considerable movement in any direction, but especially ventrally and laterally. On numerous occasions I have seen captive moles make sharp lateral turns in their tunnels. Further evidence of the flexibility of the body is seen when a mole is held suspended by a hind leg; the animal is able to reach and bite the finger that holds it. A mole placed in a round wire cage the same diameter as that of its tunnels turned around by placing its head under its abdomen and creeping under itself, so to speak.

None of the American moles deliberately take to water, except *Condylura cristata*, which is claimed to be an able swimmer. The term *"aquaticus,"* as applied to our common species refers to the webbed hind feet, which indicated to some early writers a possible use in swimming. While this inference was unjustified, nevertheless, moles, at least *Scalopus aquaticus machrinus*, can swim. When a mole was placed in a large basin of water, it swam around the edge endeavoring to escape.

Time of Occupancy of Tunnels.—Tunnels appear to be made chiefly incidental to a hunt for food, and may be used only once. Sometimes, however, they are used frequently and for a long time. One mole used a surface tunnel at irregular intervals for a month before being trapped. Another mole used a deep tunnel practically every day of the summer of 1922, and a third mole used a surface tunnel constantly during the summer of 1930. Some of the tunnels along fence lines must have been in use for years. Such tunnels may keep their shape indefinitely because they are in protected places, and often are overgrown by sod-forming plants. Tunnels may be abandoned temporarily during the breeding season and permanently during periods of drought, when the moles seek moist regions. This especially is true of tunnels in treeless tracts.

Diurnal and Seasonal Activity.—In endeavoring to learn at what hours moles worked by day (7 A.M. to 6 P.M.), I watched 20 used tunnels in a pasture. With a trowel, soil was pushed into a number of mounds, and stakes were set to mark the places. Surface tunnels were tramped down here and there, and stakes were set as before. In all, there were 355 marked places. If the mole passed through its tunnel, its passage was indicated by a repair in the mound or tunnel. The places were inspected generally 6 times a day for 4 consecutive days, making a total of 8040 observations. The time the mole passed through its tunnel was noted and the surface tunnel or mound again was filled. The observations show that some moles seem to be most active in the early morning hours, while others work later. There appeared to be one period of activity extending from 8 A.M. to 2 P.M.

These observations were continued by using a remodeled alarm clock that would indicate the time when a mole passed through its tunnel, by night as well as by day (fig. 4; A, B, C). The apparatus was in a field near Iowa City, Iowa, from June 10 to July 31, 1922. The experiment was repeated at Lincoln, Nebraska, during the summer of 1930. Five clocks were used, which were simpler and better than the original, but worked on the same principle. The clocks were in the field from June 16 to July 17, 1930, and were taken up when the moles deserted their tunnels during a period of drought and high temperatures.

Both of the clock experiments were similar in that there were more records during the afternoons than during the forenoons. For the latter there were 54 records, and the afternoons gave 72 records (table 1). A plot of the records seemed to indicate 3 periods of activity—from 2 to 6 A.M., 10 to 2 P.M., and 9 to 11 P.M. The second period tallied with the findings of the previous experiment when 8040 observations were made.

A similar experiment was conducted in another way, this time measuring the extent of surface tunnels constructed and the amount of soil brought into mounds by day and by night. A number of tunnels were watched for 8 days. During that time, 91.4 liters

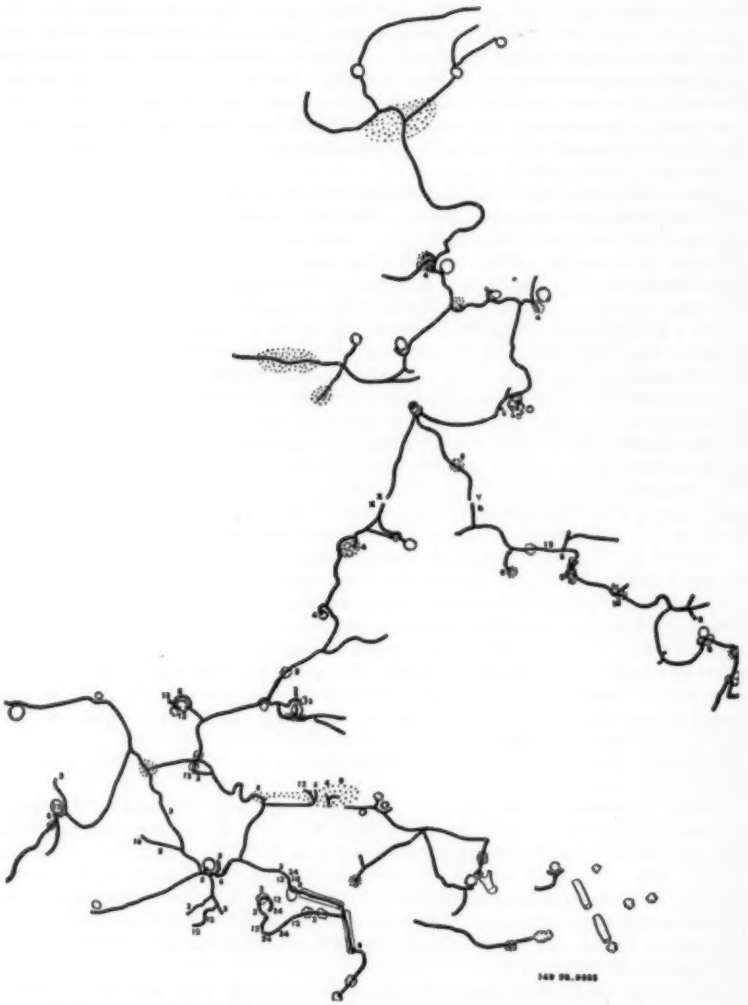

FIG. 2. The heavy line indicates a mole system covering about 3,540 square meters; near Iowa City, Iowa. Stippled areas represent bushes; round circles, stumps; scalloped circles, mounds; numbers, depth in inches; S, surface. Location of logs and isolated tunnels are shown at lower lefthand corner.

of soil were brought into mounds and 4.59 meters of surface tunnels were constructed by day. Night work was represented by 58.4 liters of soil and 2.74 meters of surface tunnels. When these findings are compared with the previous ones, it seems evident that moles are more active by day than by night. This is as might be expected, since earthworms more often come to the surface by night than by day, and there would be fewer in the soil at night.

Whether the European and the American moles cease their activities during winter has been a much debated question. Cory (1912) held that moles were able to construct tunnels by pressing the soil aside. Perhaps this, to some extent, has been a basis for the belief in winter activity. The uncertainty appears to be due to a lack of investigation. There is no clear evidence that moles can construct tunnels below frost by pressing the soil aside. *Talpa europaea* brings soil to the surface, even though the mound

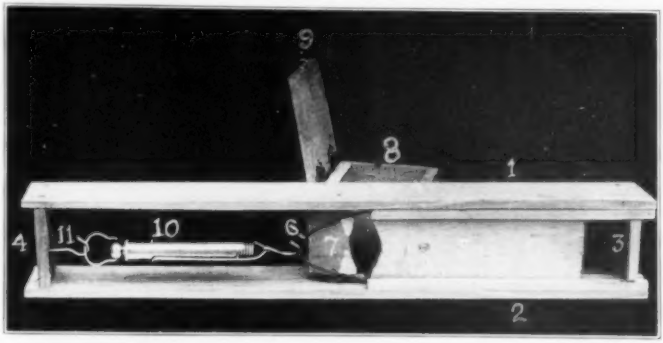

FIG. 3. Apparatus for measuring the strength of moles in captivity. 1 and 2 are top and bottom pieces attached to box 8; 3 and 4, stationary end pieces; 5, sliding door; 6, wire loop fastened to 5; 7, end piece to correspond with 5; 9, lid; 10, spring balance; 11, screw-hook. When a mole is placed in box 8, it attempts to escape through opening between 5 and 7 and slides door 5 toward 3. The power expended is indicated by balance 10.

may be covered with snow. When the ground is frozen, this would be impossible. Evidence shows that the American moles construct their deep tunnels in the same manner—the soil must be brought to the surface.

The activity of moles in winter varies with the rigor of the weather. Moles that occupy the warmer sections of a country are more active in winter than those in cooler regions. And those inhabiting areas in which the climate is modified by warm ocean currents, as western Europe and Japan, are more active during winter than moles inhabiting inland areas in the same latitude. In parts of England moles can extend their tunnels all winter and bring the soil to the surface.

Slonaker (1902) claimed that *Scalopus aquaticus machrinus* hibernates late in the fall and spends its winter in nests and in burrows that are from 2 to 3 feet below the surface. With a hatchet I cut openings into a number of surface tunnels near Iowa City, Iowa, when the ground was frozen. Wads of dried grass or leaves were pushed into the openings so that, if a mole passed through its tunnel, the wads would be pushed up. During mild weather throughout the winter, moles pushed up the wads. Frequently

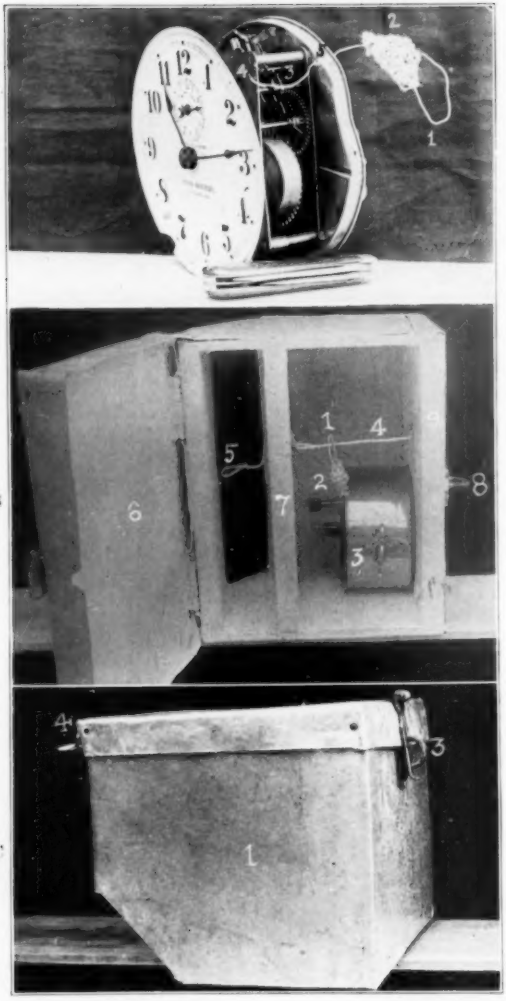

FIG. 4. A (top), an ordinary alarm clock, remodeled to tell the time when moles went through their tunnels. 1, 2, 3, 4, 5, a wire lever that interferes with the escapement of the clock; 2, a weight. When the lever is down, the clock stops. B (middle), top view of clock, and 3, a shelter. 1 and 2 same as in A; 4, 5, crank-like wire lever running to the exterior of shelter; 6, lid; 7, partition; 8, loop for hasp and padlock. C (bottom), clock shelter in upright position; 3, loop and hasp; 4, rear of shelter. When the apparatus is used in the field, the shelter is so placed that a surface tunnel runs parallel to the back and below the cut-off corner. End of lever 5 (B) rests on a trampled portion of a tunnel. When a mole passes through the tunnel, lever 5 turns and releases lever 1, which stops the clock. The shelter is held in place by stakes.

the animals used soil in closing the openings. The soil seemed to be the scrapings found within the tunnel, and not soil brought from below frost. During cold winter weather the wads remained untouched for days at a time. The observations seem to show that

TABLE 1

Times when five moles went through their tunnels during day and night, near Lincoln, Nebraska, summer 1930

DATE	TUNNEL 1 ALONG FENCE		TUNNEL 2 UPLAND WOODS		TUNNEL 3 UPLAND WOODS		TUNNEL 4 UPLAND WOODS		TUNNEL 5 GARDEN	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
June										
16		10:40	11:31	4:31						
17		3:25		10:50						2:22
		11:55								
18		9:30	5:18						11:39	9:15
			10:16							
19			4:20							
20	2:53	6:52		12:51						1:43
										6:50
21		6:30		3:01						10:40
22		7:28								2:06
23		10:28	2:55		11:26					9:15
24	10:06	9:30	10:10		7:35					
25	11:30	4:45	4:20							
26	7:34	10:00		11:39						
28		12:30								
29	2:30		3:20	12:01						
30	12:15		Deserted		5:04	9:40			1:18	4:20
July										
1	9:21								10:34	12:50
2	8:15	7:06				10:55	9:33			
3	10:01					6:11		10:10		
4	10:42	11:10			3:44	8:07		6:20	4:45	
5	6:41				7:25					
6		10:10					4:07			
7		12:18					3:29			
							9:48			
11					2:17	4:28		1:50	5:50	
12					3:11		12:19			10:39
13		11:20				1:02			Deserted	
15		1:11			Deserted					
17								6:28		
							Deserted			

the mole under consideration does not hibernate—at least not during mild winter weather.

Surface activities.—The American moles seem to be more exclusively subterranean in their habits than their European relatives. A few of the early writers, both American

and European, contended that the American moles do not come to the surface. Scheffer (1910) wrote: "The mole lives in the seclusion of underground burrows, coming to the surface by accident. He does not even permit himself the diversion of an airing at the mouth of an open burrow. Living thus in darkness, removed from the sights and sounds that attend the life of insects, birds, and mammals above him, the round of his experiences consists mainly of smells of fresh, moist earth, of plant roots, and of various worms and grubs he seeks out for food. He feels also the jar of passing feet, the trickle of percolating waters after showers, and the changes of temperature as the seasons come and go. Observations have led us to believe that the mole is not a social animal—that the very character of his environment compels him to lead the life of a hermit."

The evidence now shows that moles make occasional visits to the surface. During the breeding season, moles in isolated tunnels may come to the surface to seek their mates, but when a number of tunnels are united, as along a fence line, the moles may visit several tunnels without coming to the surface.

It is not uncommon to find openings to the exterior through the mounds or surface tunnels. There must be some use for these exits. During the present study, it has been noticed that moles seem to come out more frequently during periods of drought, at night, and on dark days, for openings to the exterior are found most frequently at such times. Occasionally openings are observed when the ground is moist, which may prove that moles may come out at any time, whether the ground be dry or moist. There could be no isolated tunnels, if they did not seek new regions. Several instances have been found in which moles have constructed surface tunnels, but travelled on the surface for short distances between. Predaceous animals, such as hawks, owls, and cats, catch an occasional mole. None of these animals are known to dig for their prey—the mole must have exposed itself when it was caught. In fact the American moles have been seen on the surface by a large number of observers, including the writer.

During winter the moles under consideration are confined to their subterranean tunnels. At Iowa City, Iowa, the winter of 1921–22 was fairly mild at times and thaws were frequent, but there was no evidence that moles came to the surface. All the used tunnels observed had no openings to the surface, were frozen over, and no mole tracks were seen on the snow. A number of frozen tunnels were opened, but not once did the moles emerge. Invariably they closed up the openings with soil, thus sealing them from within; this soil later froze.

Disposition.—Are moles tolerant towards their kind? In answering the question observers do not agree. During unfavorable seasons moles are compelled to leave the old tunnel in search of new territory. In about one-half of the instances, the ultimate result of the individual searches for food is individual tunnels, because when a mole seeks new territory, he may as often go away from other individual tunnels as toward them. Such a life in secluded darkness and, in some instances, in independent tunnels, has led a few writers to call the mole an outstanding, intolerant hermit.

Besides these evidences there are others which indicate that moles are not intolerant toward their kind. During the breeding season they associate more than at other times. It appears that in summer 2 or 3 moles may occupy the same tunnel. In 2 instances a pair was caught in the same tunnel, but at opposite ends. Several times the writer has caught 2 or 3 moles in the same isolated tunnel without moving the trap (table 2). Evidently several of the animals occupied the same tunnel. When 3 moles were caught, 1 was a female; when 2, both were males or 1 was a female. A number of males and females together may occupy several united tunnels, because such tunnels are comparatively extensive. In a series of united tunnels 3 females and 4 males (table 2) were caught. There appears to be more tolerance between males than between females. In none of the 9 isolated tunnels were 2 females caught. In another instance 2 females were caught in 2 adjacent tunnels, which showed evidence of former communication.

TABLE 2

Showing the number of moles caught in the same place in the same isolated tunnels (the first nine), and moles caught in tunnels having communication (the last six); near Iowa City, Iowa

The mole number, sex, and date are indicated. Not more than one female was caught in the same isolated tunnel, but 1 to 3 in the other tunnels.

NUMBER	SEX	DATE	NUMBER	SEX	DATE	NUMBER	SEX	DATE	NUMBER	SEX	DATE	NUMBER	SEX	DATE	NUMBER	SEX	DATE	NUMBER	SEX	DATE
											1921									
		Mar.			Apr.															
8	M	29	14	M	4															
9	M	30	11	M	2															
		May			May			May												
46	F	18	47	M	19	50	M	23												
		June			June			July												
68	M	28	69	M	29	84	F	11												
					July															
70	M	30	73	M	1															
		July																		
76	M	3	79	M	5															
85	M	11	86	M	11															
90	M	13	93	F	15															
		Mar.			Mar.						1922									
119	M	15	120	M	29															
											1921									
		May			May			May			July			July			July			July
27	F	4	29	M	5	30	F	6	113	F	2	96	M	16	97	M	16	111	M	25
								July												
28	F	4	32	F	9	95	F	15	106	M	21	114	M	26						
											June									
34	M	12	36	F	13	38	M	14	62	M	18									
					June															
51	F	24	57	M	3															
		June			June			June			July			July			July			
67	F	28	115	M	28	72	M	30	74	M	1	77	M	3	82	M	7			
					July			July												
65	M	21	78	F	3	81	M	7	92	M	14									

It seems that the 2 moles had associated at one time, but had become intolerant and discontinued communication by filling up a portion of the tunnels at the point of contact.

During the present experiments 2 male moles, a large and a small one, were placed together in a box containing about 10 cm. of soil. Both moles tunneled through the soil until they met. Immediately they attacked each other with teeth and claws, but in a short time separated. There appeared to be no attempt on the part of either to search for or to pursue the other, but both tunneled again until they met and then fought as before. When both moles were on the surface of the soil and the larger one discovered the other by scent, he hurriedly tunnelled under the other, and by a sharp and quick movement with the front foot thrust the smaller mole out of the way. These observations seem to indicate the disposition of moles toward their kind; but it must be remembered that the moles were in a box where there was no opportunity for escape, and not in their native habitat.

Scalopus aquaticus machrinus and *Scalopus aquaticus machrinoides* in captivity seem to have quiet dispositions. When gently disturbed they either escape or prepare for an attack. When unduly teased, they lie on the back, utter shrill squeaks and defend themselves with teeth and claws. They push aside with the front feet objects such as sticks placed against the body, and try to grasp them with the teeth. If moles succeed in biting an object, it is held with bulldog tenacity; a dog was seen coming home from the field with a mole suspended by its teeth from the dog's lip.

Nest.—The American moles do not build large hills and galleries. Their hills, if they may be called such, really are low mounds, rarely with any tunneling within. The nest is simple, and it may be from 8 to 46 cm. or more below the surface. During the present study no nests were found under logs or bushes, but a few were placed under the large roots of stumps. A number were in the open ground without any protection from above. The nest is situated in a hollow dome about 20 cm. in diameter and 12 cm. deep. It may contain dry leaves, grass, or nothing at all. Communicating with one nest was a series of tunnels on the opposite side of the stump. Near the surface behind the stump was also a smaller nest.

Mating season.—During the present study 125 moles were caught: 81 males, 43 females, and one of unidentified sex. The number of embryos is 4 or 5; in one instance only 1. All of the embryos were hairless. According to the observations, mating must have taken place about March 20. Moles nos. 41, 42, and 43 were young, but nearly of adult size. They were estimated to be about 4 weeks old, which sets the date of their birth at about April 15. On April 18 mole no. 20 had five 4-cm. embryos, almost at term. The period of gestation appears to be about 6 weeks. If there is a second mating, this must be about the middle of May, when the first litter of young will have reached maturity and become independent. The end of the second period of gestation would then be about the first week in July. Mole no. 67 contained a 4-cm. embryo on June 28. Since but one mole with a large embryo was caught about this time, a second general period of gestation is doubtful. Moles nos. 75 and 78 had minute embryos in the first week of July. The period of mating for these moles must have been about the last week in June. But since there were no other embryos found after July 3, mating in June or July must be rare, and this instance does not indicate a regular mating period.

The observations recorded seem to indicate that moles nos. 2, 5, 6, 13, 17, and 20 would have given birth to young during the last two weeks in April or the first week in May. During this time the moles that had given birth to young must have been more or less confined to their nests, for no animals with suckling young were caught at this time. The females that were caught during the three weeks mentioned were without embryos and had not given birth to young. These data point to a definite season of

birth; namely, the latter half of April and the first week in May. This further is substantiated by the fact that moles nos. 39, 51, and 54, as judged by their appearance, were suckling young. The latter, perhaps, were nearly of adult size, for moles nos. 41, 42, and 43, still dependent upon the parent, were as large as a small female mole. The three young moles observed apparently were under parental care, for their stomachs were filled with milk.

Food and Feeding.—The food of moles consists mostly of worms, insects, and insect larvae, which are devoured in great quantities. Plant food occasionally is eaten in small amounts. Herrick (1892) quoted Webster as saying that 2 moles in 9 days ate 341 white grubs, 193 earthworms, 25 caterpillars, and a mouse, both the bones and the skin of which they swallowed. Brehm (1890) stated that the appetite of moles is insatiable. Daily they need as much nourishment as the weight of their own body. Vogt and Specht (1888) quoted Geoffroy St. Hilaire as follows: "The mole does not suffer from hunger like all other animals. In it this appetite is heightened. It is an exhaustion felt even to frenzy. The animal exhibits a violent agitation. It is animated with fury when it darts on its prey. Its gluttony disorders all its faculties; nothing is allowed to stand in the way in its effort to assuage its hunger; it abandons itself to its voracity, whatever may happen, neither the presence of man nor obstacles, nor menace deter to stop it."

During the present study the same phenomenon has been observed. Moles caught with the mole trap, which inflicts severe or deadly wounds by sharp prongs that penetrate the body, if still alive, may eat earthworms placed within reach.

Hisaw (1923) fed 6 moles for 36 days with the object of discovering what kinds of food they ate, and in what quantities. The seeds fed were soaked in water, and all food was fed on sifted soil. The percentage of animal food eaten was 72.52 and of vegetable, 20.15.

During the present experiment 2 moles were kept in suitable bins and fed various kinds of foods. All the food except bulbs, tubers, etc. was put in trays measuring 12 x 12 x 3 cm. The edges of the trays were turned in at a right angle, which prevented the earthworms from escaping. The trays were placed on the floor of the bin where there was no soil. Seeds that were carried out of the tray on the feet of the moles could easily be recovered on the floor of the bin. Earthworms, white grubs, liver, and beef were fed to supply the necessary animal food. Incidentally, two mice and a frog were captured and fed to the moles. An entire mouse was eaten by one mole. The vegetable foods offered were: beans, peas, corn, wheat, oats, squash seeds, muskmelon seeds, watermelon seeds, carrots, dahlia roots and shoots, gladiolus bulbs, roots, and shoots, hyacinth bulbs, roots, and shoots, and potatoes. The seeds were soaked in water over night before feeding, but there was no attempt to "tease the appetite" of the moles by mincing the bulbs and tubers; they were moistened and left on the moist soil of the bins. The moles were fed twice daily and the trays were kept clean. Seeds that were soiled were removed and replaced by clean ones.

The experiment showed that beans, peas, and watermelon seeds were not eaten readily by the moles, and that roots, shoots, tubers, and bulbs were not eaten. Corn, wheat, oats, muskmelon seeds, and squash seeds were eaten at practically every feeding. Corn was offered 37 times and eaten 35 times; 120 grains were consumed, and one mole ate 10 at one feeding. Wheat was offered 26 times and devoured 21 times; 181 grains were eaten, and one mole ate 18 grains, while the other ate 20 at one feeding. Oats were offered 33 times and consumed 30 times; 137 grains were eaten, and both moles ate 20 grains at a single feeding. Squash seeds were offered 31 times and devoured 24 times; 95 seeds were eaten, and one mole ate 10 at one feeding. Muskmelon seeds were offered 23 times and consumed 19 times; 215 seeds were eaten, and one mole ate 20 at one feeding.

The writer has observed the manner in which individuals of *Scalopus aquaticus mach-*

rinus eat an earthworm. Taking the worm in its mouth by one end, the mole brings the fore feet close to the mouth, presses them against the worm, and slides them downward. Piece by piece the worm is thus imperfectly cleared of soil within and without. Usually, however, there is no attempt to clear the worm of soil before eating it. For the most part the mole quickly slides the nose along the worm until one end is reached. It then is seized with the teeth, taken into the mouth, masticated, and swallowed. The claws and dorsal side of the manus aid in straightening the worm before ingestion. When beef or liver is fed for the first time moles may run their nose along the surface apparently feeling for an end to grasp. One mole devoured a mouse and a portion of a frog by eating the feet first.

Sleep.—Moles assume various positions during sleep. In one position the animal is stretched out completely and lying on the belly. A second way is to stand on all four feet, hump the back, and tuck the nose well under the chest. A third manner is to lie on the side, but because the fore feet are short one of them is held suspended. A fourth way is to recline against an object. In this position the mole rests the anterior part of the body on the object, and the hind feet are on the substratum. At times, while asleep, moles may be seen moving the anterior limbs and nose, as though digging.

STRUCTURE AND ADAPTATIONS

The modifications which adapt the mole to its peculiar subterranean life constitute a most remarkable example of animal specialization. The fur is velvety and offers scarcely any resistance to the animal's passage within the burrow. The body is somewhat depressed dorsoventrally, and in comparison with the smaller and weaker posterior part it is rather thick and clumsy anteriorly. The difference is more noticeable when the skin is removed. There is no visible neck; the conical head seems to emerge directly from the shoulders and terminates in a more or less cartilaginous snout, at the extremity of which the nostrils open. There are no external eyes or ears to catch the dirt as the mole tunnels through the soil. The tail usually is short and naked, and serves as an organ of touch.

Pelage.—The fine and velvety hair of the mole, contrary to a common belief, does not stroke as easily backward as forward. Moles are born hairless, but the skin is dark in color. At the age of about 4 weeks the fur is quite light. Under low power magnification an individual hair shaft appears wavy and varies in thickness and pigmentation. At the crest of the wave the hair is thinner and the pigment is limited to the center of the shaft. Between the crests the pigment is arranged in numerous rows, which run at a right angle to the shaft. The proximal end of the hair is more or less spindle-shaped, thicker, and lighter in color than the rest of the shaft.

It is thought by some (Jackson, 1915; Scheffer, 1917) that moles have two molting periods. In eastern Iowa a large number was found to be shedding during May, and a few during July. If there be two periods, one would expect to find an equal number shedding at both times. A number of late molters caught near woods suggests that these moles shed later than those in treeless tracts. Frost does not disappear from the ground in shady places as quickly as it does in open ground, and extended cold weather and cold soil may delay the shedding period. I have not found sufficient evidence to claim that there are two molting periods in the vicinity of Iowa City, Iowa. Molting seems to follow a definite course at times, especially in the initial stages. It begins on the ventral side and spreads anteriorly, posteriorly, and laterally; the dorsal surface molts last. On the dermal side of the skin is a dark linear pattern that coincides with the pattern on the fur side.

Skeleton.—The important fossorial adaptation of moles is the great increase in size of the pectoral girdle and of the anterior limbs. The whole girdle has moved forward close to the skull. The change of position is due in large part to great development of

the presternum. In addition to being greatly elongated, the presternum has developed a strong ventral keel, providing a large surface for the attachment of the powerful pectoral musculature, the thickness of which is suggestive of the breast muscles of birds. The shoulder muscles also are greatly developed.

The scapula is much elongated, equaling the combined length of the humerus and radius, and the posterior portion is greatly expanded, increasing the area for the attachment of the muscles.

The clavicle has experienced extreme modification. The bone is short and thick, and able to withstand the strain placed upon it when the mole is digging.

The humerus has been so greatly modified that it would be difficult to identify it out of its natural position. It is very short and thick, and its surface irregular, increasing the angles of leverage of the muscles concerned.

The radius is short and oval in outline. The greater diameter lies in the plane of movement of the forearm. The ratio of average diameter of the shaft to the length of the bone is 1:17 in man, while in the mole this ratio is 1:6.

The ulna is modified more than the radius in that the elongation of the olecranon extends well proximal of the elbow joint.

The eight carpals are largely similar to those of other mammals. In the flesh the palm is large and measures 15 to 20 mm. in length and 20 to 25 mm. in width. The great width is increased by a flap of skin on the radial side and is kept rigid by an additional semicircular sesamoid bone, which is attached to the distal end of the ulna at the wrist. The palm is hairless, but stiff hairs occur along the margin. The palms are set at a right angle to the body, making them very effective in digging. The five short fingers are almost united to the tips, and are armed with strong, ventrally flattened, and almost straight claws.

The vertebrae are of the usual mammalian type, except that the transverse processes are relatively short. This permits great flexibility of the spinal column, making turning easier.

The ribs are comparatively slender and flexible, permitting great freedom of movement.

The pelvic girdle had experienced a reduction in size, and has attained a horizontal position, which may permit the animal to turn in its burrow with greater ease.

The hind limbs of the mole are smaller than those of most other mammals of corresponding size. The claws are slender, and the entire foot suggests weakness.

Teeth.—Moles have both deciduous and permanent teeth. The dental formulae are;

$$\begin{array}{lcccccc} & \text{i} & & \text{c} & \text{p} & \text{m} & \\ \text{Deciduous teeth:} & \frac{3-3}{3-3}, & \frac{1-1}{1-1}, & & \frac{3-3}{3-3}, & \frac{3-3}{3-3} = \frac{20}{20}, & \text{or } 40; \\ \text{Permanent teeth:} & \frac{3-3}{2-2}, & \frac{1-1}{0-0}, & & \frac{3-3}{3-3}, & \frac{3-3}{3-3} = \frac{20}{16}, & \text{or } 36. \end{array}$$

According to Owen (1868), the deciduous dentition of moles and shrews is limited to the intra-uterine period and disappears before birth. The teeth are very small and are all of the most simple form. At 4 weeks 2 of the deciduous incisors remain in the lower jaw.

The teeth of a mole four weeks old (no. 41) were loose and were covered with a thick membrane. The stomach contents of three such moles were examined, and no earthworms, insects, or any kind of solid food were found; but the stomachs were full of milk. When the membranous covering of the teeth was removed, the functional dentition was revealed. In the young mole examined there was an additional slender

tooth on the left side of the upper jaw just anterior to the third premolar. This tooth, perhaps, was the last of the deciduous dentition.

Sense organs.—To be able to study the mole more effectively than is possible in small quarters, an electrically lighted room 2.5 x 4.5 meters was chosen. The floor was of concrete and the walls of tile. A board 30 cm. wide was nailed across the doorway. The walls were marked off into a number of equal units, and the floor space into 4 equal sections. About 8 cm. of garden soil was spread over the floor and kept at a uniform depth by means of a gaged scraper constructed for the purpose. The soil was kept moist by spraying with a garden hose. A mole then was released in the center of the room. When the mole had done considerable tunneling, drawings were made of its movements, and the tunnels then were smoothed over by the use of a garden rake. The experiment was repeated for a number of days and the various drawings were compared.

By comparing the drawings it was observed that at first the mole tunneled to an equal extent in each section of the room, and from day to day decreased the tunneling in three sections but increased the activities in the southeast section. At the close of the experiment the tunneling was largely limited to this section. The mole seemed to be more content in this spot, which may have been due to chance.

From a comparison of the drawings a number of interesting deductions were made. At first the mole spent considerable time running along the walls in seeking a means of escape. Later it was occupied more in tunneling.

That location was an important factor in the mole's ability to return to the same section from time to time was indicated by several observations. It is very doubtful that the animal could or did return by scent. The consensus of opinion among writers is that a mole is not able to locate its food by scent at distances of more than a few centimeters. The writer has verified the observation on a number of occasions. When a white index card was placed along the east wall, the mole ran into it twice; after that the animal remembered where the card was, and approached it cautiously. On a number of occasions when the mole left its tunnel, it could, when disturbed by noises, return to its burrow with remarkable accuracy. The path by which the mole returned was not always the same as the one taken in leaving the tunnel. At times short cuts were made, which showed that the mole returned by a sense of location and not by scent.

Nose.—In the mole the nasal passages are longer than in most other mammals. The distance from the nostrils to the distal surface of the olfactory lobes, and from this point to the foramen magnum bear the approximate ratio 3:1.75, while in the dog this ratio is about 1:1.

The two groups of moles studied during the present observations did not seem to notice earthworms unless they were placed a short distance from the snout, suggesting that the sense of smell is poorly developed. These observations can hardly be regarded as proof, however, for the moles were not in their natural environment during the experiments. A mole is rather sluggish in captivity. On several occasions I have held several injured moles in my hand. Although practically inactive while being held, they manifested surprising energy when placed on the ground. The stimulus received from contact with soil makes a mole a different creature.

Eyes.—The edge of the upper eyelid forms a small crescentic slit, and a bead-like structure marks the remnant of the lower lid in some moles. With a mounted needle I have made numerous attempts to open the eyelids of fresh and preserved moles, but without success. When the skin is carefully flayed over the eye, this organ usually accompanies the skin, for it is imbedded in the subcutaneous fatty tissue of the dermis. The eye is not within its orbit in the skull as in other mammals. In fact muscles run across the orbit, leaving no trace of its position.

When the eye is removed from the skin with a pointed forceps, a "socket" remains

in the subcutaneous tissue and the eye appears normal as to color (black), form, and size. By holding the skin to the light no opening between the eyelids could be discerned; they appear fused when viewed from the inside and the outside. The integument over the eye is thin, and light passing through it is much diffused. There are variations, however, with respect to the degree of fusion of the eyelids, as cross-sections show. There are gradations from a microscopic opening to complete fusion. But the passageway is more or less tortuous and not along the axis of vision. According to Slonaker, many of the nerve fibers extend only a short distance beyond their exit from the eyeball. Weak eye muscles are present.

Slonaker studied the histology of the eye of the young and adult moles. Sections were made 5, 10, and 15 micra thick. Various fixing agents were used, but Perenyi's fluid, potassium bichromate, and formalin proved most valuable. The following stains were used: Ehrlich-Biondi, Weigert, Minot's (23) haematoxylin, haematoxylin-eosin, and hemalum. I used formalin as a fixing agent, and hematoxylin as a stain.

The transverse sections of the eye of young moles *in situ* usually show it to be spherical in outline. The cornea appears normal as to position, thickness, and curvature. The sclera, choroid, and retina are present. The sclera covers the basal five-sixths of the eyeball. The choroid coat extends almost to the cornea, and it is comparatively thick and intensely pigmented. Slonaker stated that all of the elements of the retina have been observed, except perhaps the rods and cones, and it practically fills the whole of the vitreous chamber. The optic nerve cells, or ganglion cells, show considerable departure from the usual mammalian type. Sometimes they form a layer several cells deep, or they may be crowded into a mass. Lack of regularity in this layer is considered abnormal. The cells of the inner molecular layer are unusual, because they are irregular and vary in size. The outer nuclear layer is abnormal in that the nuclei are elliptical. The rods and cones are absent or poorly developed at this time. The other layers of the retina conform to type. The aqueous and vitreous chambers seldom are seen. If a vitreous chamber be present it is very small and located just anterior to the entrance of the optic nerve. Usually the vitreous chamber, if it can be called such, is filled with the retina. The iris is more pronounced in some eyes than in others. The lens appears usual as to position, form, and size in most cases, but occasionally there are striking variations. One lens appeared as though a bud were growing from one side. The structure of the lens departs much from that of the typical mammalian eye. The nuclei of the cells are large and so crowded together as to resemble cartilage cells. The cells also are very irregular, and have irregular processes extending in various directions. Vacuoles often are present within the cells. The anterior surface of the lens is covered by a single layer of cells, but the lens lacks the concentric layers commonly found in mammalian eyes. It is in the cell structure of the lens that there exists the greatest abnormality. With cells irregular in form, size, and placing, it hardly is possible that the lens can produce any but a distorted image upon the retina. The optic nerve and blood vessels enter the eye in the usual manner, and the internal blood supply appears to be normal.

The eye of the adult mole is similar to that of the young, except that it is larger. In the adult it measures 1 mm. in diameter. The eyeball is naked and mostly black, except where connective tissue covers the posterior portion. Slonaker stated that both the aqueous and the vitreous chambers sometimes are present, sometimes only one is seen, and in other instances neither is found. I have not found either of the chambers absent in any of the eyes examined. Both chambers appear natural, and variation in size may be the result of shrinkage caused by fixing agents. Slonaker further stated that all of the elements are present in the retina, but that they are not arranged in the usual manner. The elements of the layer of optic nerve cells (ganglionic layer) have no definite arrangement. The cells in some instances compose uniform layers, while in

others the cells are massed. In the usual mammalian eye the optic nerve cells form one or two irregular rows; but in the mole there are more than two rows, because of the confusion of the cells and nerve fibers. Furthermore, the axones of the ganglionic cells are approximately parallel with the layers of the retina, while commonly they are vertical to them. The inner molecular layer varies in thickness, but may function normally. The inner nuclear layer is the same as in the young at birth; it is the most atypical layer of the retina. The outer nuclear layer closely resembles the same layer in other mammalian eyes. Rods and cones are present; they were absent or undeveloped in the eye of the young mole. The other elements of the retina appear to be typical. The lens varies in shape from normal to irregular, even those from the same individual not always being alike. The writer has not encountered any eye without a lens. The cell structure of the lens of young and adult moles is similar. The cells are irregular in shape, irregularly grouped, and often vacuolated. Such abnormalities preclude a perfect retinal image, since at best only diffused light can reach the retina, and there can be no clear vision. The inner parts seem to be well supplied with blood vessels.

Ear.—The pinna or concha in fossorial types tends to atrophy, for its position is such that it would fill with soil, and therefore would prove a hindrance rather than an aid in hearing. When the hair is clipped from around the ear of *Scalopus aquaticus machrinus*, the pinna appears as a small protuberance on the surface of the skin. In the center of the prominence is an opening one millimeter in diameter. Close examination reveals the fact that the protuberance is not formed of the pinna alone. When the skin is removed from the region of the ear, the external meatus easily can be seen. It is 3 millimeters in length and seems to push the skin outward a little, adding to the height of the prominence. In other words, the pinna appears larger than it really is. The pinna, if it can be called that, has atrophied to a mere cartilaginous ring covered with skin. Hairs are absent from the surface of the ring save for a little arc above the posterior border. Where the pinna has suffered the greatest reduction it is practically devoid of hairs.

The external meatus enters the bony wall of the tympanic bulla from the side and ends near the tympanic membrane. The tympanic bulla of a mole occupies the same relative position on the ventral side of the skull as in other mammals, just posterior to the condyles of the inferior maxillaries. It is not as prominent as in the domestic cat, because it is compressed dorso-ventrally.

As far as observed there has been no atrophy of the ear excepting the pinna. The compression of the tympanic bulla is not considered as atrophy, but as an adaption to a fossorial life. The structures of the middle and inner ear apparently are normal and comparatively large. Accordingly, one would expect efficiency in hearing; and there is evidence to show that moles hear very well. According to Brehm (1890), *Talpa europaea* hears exceptionally well. During the present observations the animals studied have been found to hear excellently. One would have to exercise considerable care in turning a door knob, closing a door, walking on the floor, whispering, or in turning the pages of a note-book, if he did not desire a mole to hear the sound. Moles have nervous susceptibility to sounds, and are very cautious about their own safety.

ECONOMIC STATUS

Earthworms compose most of the food of moles, and these are beneficial to agriculture. But moles also eat a large number of destructive larvae and insects, which compensates for the harm done in eating useful worms.

There is much complaint about the destructiveness of moles in field and garden. The American moles have been accused of devouring the seeds of various garden plants, eating bulbs from flower beds, and of following the rows of planted corn to eat the seed.

FIG. 5. A, B, C, D, E. Five tunnels from as many corn fields; heavy lines, tunnels; lines with crosses, fence; M, corn plant missing; N, corn normal; O, hills of corn. The rows of corn run the length of the plate. The mole seems to have made effort to reach hill X in tunnel E. The dotted lines in D indicate extra rows of corn planted at right angles to the original planting. There is no indication that moles attempted to follow the rows.

The feeding experiment indicates that there is some justification for these complaints. They may not eat the seeds of beans, peas, or watermelons, but they do eat those of corn, wheat, oats, squash, and muskmelon. Roots, bulbs, tubers, and shoots may not be touched. In small gardens the presence of moles is undesirable. Here the rows are close together, and therefore considerable damage may be done in a short time by loosening of the plants as the moles tunnel under them.

For several seasons I have examined a large number of corn fields overrun by moles, and I did not find an instance where the animal deliberately followed the rows (fig. 5; A, B, C, D, E). The mole tunnels take a more or less erratic course through the field, but not a single instance was encountered where the mole tunneled from one hill of corn to another. The visiting of hills by moles seemed to have been accidental. A number of disturbed hills were dug up and the plants examined. The seed was missing from some of the plants, while in others it still was intact. Since moles do not deliberately search for the seeds or follow the rows of corn, comparatively little damage is done. Sometimes pine mice follow mole tunnels and do the damage ascribed to moles.

The damage done to young corn plants is not due to the removal of the seed so much as to the breaking of the roots and the lifting of the plants as the mole raises the roof of the tunnel. The soil over a tunnel dries faster than elsewhere, and disturbance of the roots may destroy a plant in a few days of dry weather. During a period of rain, practically all injured plants may recover. Corn 20 cm. high may not be seriously injured by moles tunneling under it.

In the fall of 1922, near Iowa City, Iowa, I examined a number of mature hills of corn under which moles had tunneled. Four fields were chosen at random, and a comparison was made between 29 hills of disturbed rows and the same number of hills of adjacent undisturbed rows. The hills of corn were compared as to the number of stalks and the number, condition, and length of the ears. The observation showed that in the disturbed hills there were one more stalk, 6 fewer ears, 5 fewer normal ears, and 142.24 cm. less corn on the cob. If these differences may be taken as a criterion, it appears evident that moles to some extent do injure corn plants by tunneling under the hills. But cutworms do more harm to corn than do moles. These worms often ruin entire fields of corn, and in comparison the injury done by moles is negligible. Since moles destroy many cutworms and really are beneficial, they should not be destroyed.

The present contribution comprises no. 187, Studies from the Department of Zoology, the University of Nebraska.

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IMPROVEMENTS IN LIVE TRAPPING

By A. W. Moore

For many years I have used the tin-can mouse trap combination described by T. H. Scheffer (Jour. Mamm., vol. 15, pp. 197–202). Two difficulties have appeared, however, one being that about half of the catch was squeezed fatally between the springing door and the can, and the other, that it was difficult to fasten the can firmly to the frail wooden base of the trap.

A method for correcting these disadvantages is shown in figure 1. Number 1 in the illustration shows the extension soldered to the trigger; no. 2 the

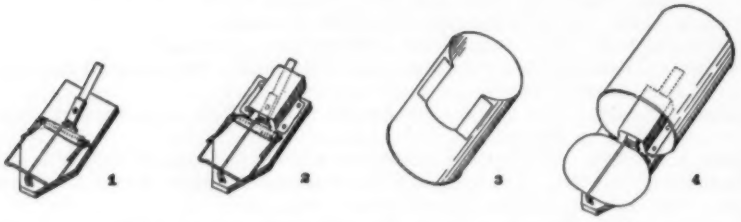

Fig. 1. An improved type of live trap for small mammals

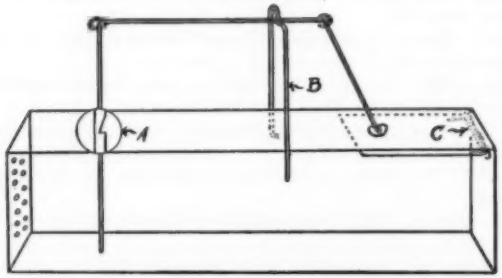

Fig. 2. Diagram of sheet-metal box trap for catching mammals alive. *A*, notched wire, 9 gage; *B*, fulcrum; *C*, coil spring for closing door.

"trigger guard" fastened to the trap base with clinched half-inch flat-headed wire nails; no. 3 the number two size can cut out, the cut edges bent back ready for soldering to the "trigger guard" base; and no. 4 the completed trap. The lid of the can has been used for the door by bending over and soldering the top of the loop wire.

Contact between the door and the can should be at the top of the door only, allowing a space of about one-fourth inch between the edge of the can and the door at the base. This spacing allows for tail clearance of the long-tailed species.

It has been found that not all types of block mouse traps will carry the trigger extension. Unfortunately, the more recent metal-trigger types present the greatest difficulty. Best results have been obtained with the use of the old style wooden-block, metal base trigger having the inverted U engagement with the release bar. In some instances it may be necessary to construct an entirely new trigger.

The diagram (fig. 2) is patterned after the Lewis gopher and mole trap manufactured by the Lewis Trap Company, of Tillamook, Oregon. I first saw it about 1925, at which time it carried the notation "Patent Pending." For live-mole trapping it has been found ineffective as compared with a tin-can—Reddick mole trap combination. For *Thomomys*, with the exception of the forms *bulbivorus* and *townsendi*, a sheet-metal box 2.5 inches square and 11 inches long is satisfactory. For larger species the box should be 3 inches square and about 15 inches long.

By making the bottom of the box from hardware cloth of one-half inch mesh, the trap can be worked into loose soil in the bottom of the excavation, thus effecting a dirt bottom to the trap.

"A" shows a sharply notched 9-gage wire. The shoulder of the notch catches on the lower edge of a cleanly punched hole, the hole being about one-sixteenth of an inch greater in diameter than the wire. The novice may find it advantageous to drill a half-inch hole where needed, and to solder in place a piece of medium gage sheet iron containing the proper size hole punched at a local tin shop. "B," the fulcrum, consists of a wire loop engaged in holes punched in the sides of the box. It may be folded down when not in use, simplifying carrying and packing. "C" is a coil spring; but a piece of inner tube may be employed as the door-closing mechanism by attaching it to the box above the door and to the lower outer side of the door.

This trap is intended for main runway sets and is not baited. Naturally, two traps should be used, one for each end of the exposed run. A double-door trap may be constructed by using one notched wire, two fulcra, and two lever bars. The top of the notched wire has a right-angle bend and laps over the free ends of the lever bars.

In another modification of this type of trap the door is made to swing in. This requires a longer lever bar but a shorter fulcrum and notched wire. Some sort of lock is needed to keep the door in place after the trap is sprung. A small piece of springy tin is probably the most simple. Baiting is done by scattering small particles of the bait on the floor of the trap below the wire trigger.

Metal traps are best adapted for use in above-freezing temperatures. Placing nesting material within the trap has not proved satisfactory. With *Microtus* the practice has been to lock the door open over night. This is done with the tin-can mouse trap by inserting a shingle nail through the release bar staple and over the door. On the notched bar type a block is

inserted, propping up the door. The traps should be left well baited and the following morning, after they are unlocked and put back in use, one is rewarded by a comparatively high catch.

For nocturnal forms, winter offers a greater handicap with these metal traps. My practice has been to run the lines several times after nightfall, with the aid of a flashlight or gasoline lantern. After the last run for the night the traps may be locked and baited. Here again prebaiting rewards one's efforts the following night.

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ELECTRICAL EXCITATION OF THE CEREBRUM OF THE KANGAROO RAT

By William L. Straus, Jr.

Very little is known about the functions of the cerebral motor cortex in those mammals exhibiting extreme specialization of the locomotor apparatus. Especially is this true with respect to leaping forms capable of bipedal progression. In such animals it seems of interest to ascertain the extent to which the hind limbs are represented in the motor cortex, with a view toward determining the rôle played by the motor neopallium in saltatory locomotion. The Vogts (1907) electrically stimulated the motor cortices of three specimens of kangaroos, namely, *Macropus dorsalis*, *Petrogale penicillata* and *Onychogale frenata*. Hind leg movements were obtained from both *Petrogale* and *Onychogale*, but the responses chiefly were limited in extent and frequently required the application of a strong current. They were in no manner locomotor in type. Tail movements were not observed. The points from which these hind limb movements could be elicited were located in the most dorsal part of the motor area, near the crest (*Petrogale*, *Onychogale*) and on the medial surface of the hemisphere (*Petrogale*). As far as I am aware, electrical excitation of the motor cortex has been attempted in no other saltatory mammal.

I have had the opportunity of stimulating the cerebral hemispheres of 7 specimens (8 hemispheres) of the saltatory rodent *Dipodomys agilis simulans*, secured in California. The genus *Dipodomys* (family Heteromyidae) occurs in western North America, extending from Montana to the Valley of Mexico, and from Kansas and Texas to the Pacific Ocean (Howell, 1932). Generally, *Dipodomys* is found in the open country, but is not confined exclusively to such a habitat. The smaller forms are about half the size of a white rat. *D. agilis* is one of the larger members of the genus. A specimen at hand has a head and body length of 11.5 cm. The tail always is somewhat longer than the body. The hind legs, as in the kangaroo *Macropus*, are more than twice as long as the fore legs. This discrepancy is even more pronounced when the

physiological length of the hind leg is considered, for, as Howell (pp. 387, 522) has pointed out, *Dipodomys* is essentially a digitigrade animal when progressing at other than a slow gait.

Dipodomys exhibits two fundamentally distinct modes of locomotion (see Howell). In very slow, deliberate walking the animal creeps in the manner of most rodents, using all four extremities, and with the tail dragging behind. This is the diagonal mode of progression seen in most mammals. At rest, however, the fore legs are held free of the ground, so that the animal is supported solely by its hind legs (see fig. 1). The second type of locomotion is not diagonal in character, but involves a hop or leap. Hence more rapid progress may be accomplished by means of a slow hop, in which the fore feet are first placed upon the ground, these being followed by a forward movement of the hind feet in unison. Finally, as a more extreme variant of this method,

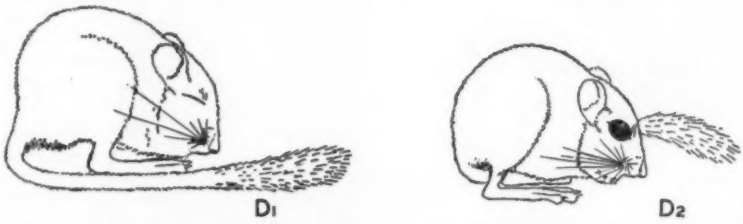

FIG. 1. Resting postures of *Dipodomys* (after Howell, 1932). D_1, lightly dozing; D_2, alert.

very rapid locomotion is effected by a graceful kangaroo-like hop—from which the animal derives its vernacular name of "kangaroo rat"—the hind legs working as one, with the fore legs at least partially flexed and held well off the ground, and with the tail pointing stiffly toward the rear. The distance covered may be considerably in excess of six feet; this is quite remarkable for so small an animal. When the hop exceeds this length coördination tends to be poor. The importance of the long tail both as an equilibrator and as a rudder is quite evident. According to Howell, if this member is lost or even greatly shortened the animal is handicapped seriously in its long leaps and may even turn completely over in midair.

I am greatly indebted to Dr. Marion Hines for her generous advice, particularly respecting interpretation of the cortical cytoarchitecture. I also am grateful to Mr. James F. Didusch for his skillful execution of figure 2.

Cortical Stimulation.—The kangaroo rat is lissencephalic, the cerebral cortex exhibiting only a rhinal fissure. The pattern of the blood vessels is too variable to serve other than as a rough guide to the location of the stimulable cortical areas. The brain is compressed laterally by the peculiar conformation of the skull, so that much of the cortex that occupies the lateral surface of the hemisphere in other mammals is elevated, as it were, dorsally.

All operations were performed under ether anaesthesia. The cortex was exposed by removing the skull with a pair of small rongeurs, and then cutting and reflecting the thin dura mater. Bleeding rarely was profuse, and this readily was controlled by the use of bone wax or by the application of a fresh piece of the masticatory musculature. Stimulation of the brain was carried out with a sinewave current of 60 cycles, making use of a device designed by J. A. Myers (see Boynton and Hines, 1933). The stimulating electrode was of the unipolar spring type, while the indifferent electrode was a piece of copper plate wrapped in raw cotton soaked in physiological NaCl solution which was applied to a shaved area on the back of the animal. Responses following stimulation of the cerebral cortex could be secured by a current of from 1 to 1.5 volts. Above the latter figure the movements produced invariably were characteristic of "spread of cur-

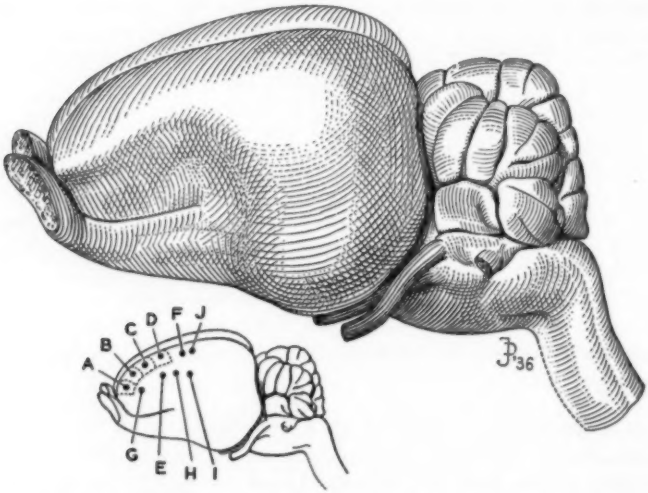

FIG. 2. Brain of *Dipodomys agilis simulans* (×5), with insert showing approximate extent and location of the electrically excitable areas of the cerebral cortex.

rent." The cortex responded to stimulation only when the animal was under light anaesthesia. When under deep anaesthesia movements could not be produced, even though a very strong current was used. The resistance was measured in one animal 5 times during the course of the stimulation, and ranged between 3500 and 5000 ohms (average 4000 ohms). Since the average threshold voltage is about 1.25 it can be concluded that the minimal current necessary to produce a response in the kangaroo rat is about 0.0003 ampere.

The stimulable cortex in the kangaroo rat is practically confined to a relatively narrow area beginning near the base of the frontal pole, well above the rhinal fissure, and extending upward in an arc carried backward along the crest of the hemisphere (see fig. 2). For purposes of convenience, this region has been subdivided into 4 roughly equal areas (A, B, C, D). These individual areas, however, are to be regarded as only approximately comparable among the several specimens; for, undoubtedly, in some instances, a given area (as A) in one specimen may overlap even to a considerable degree

an adjacent area (as B) in another specimen. In addition, responses were obtained in a few animals from other points on the lateral surface of the hemisphere (E, F, G, H, I, J), as indicated in the accompanying figure; furthermore, the medial surface was stimulated in four specimens, with definite reactions in three instances. The responses elicited by cortical stimulation involved face, head and fore limbs, but unequivocal movements of either hind limbs or tail never were secured.

Area A:—This may be regarded as one essentially concerned with movements of the facial musculature (vibrissae movements, with less frequent response of the upper lip and closure of the eye). Movements of the fore leg were noted in one animal, and of the head in one.

Area B:—Facial movements (vibrissae) also predominated in this area. Fore leg (and head) responses, however, were not uncommon.

Area C:—This is a fore leg area, inasmuch as movements of this extremity, many of a complex nature, were secured from this region in all but one animal. Vibrissae movements, however, by no means were rare, while eye closure was noted in two specimens.

Area D:—This likewise is dominated by fore leg responses, which occurred in 5 of the 8 hemispheres. Vibrissae movements were seen in 3 animals, and eye closure in one.

Area E:—This region was unresponsive except in three animals. In one rat there were noted movements of the vibrissae; in a second, closure of the eye; and in a third, movements of the fore limb.

Area F:—This likewise was responsive in but two animals (vibrissae and fore leg movements in one; fore leg alone in the other).

Area G:—Two animals only responded with vibrissae and fore limb movements.

Area H:—Movements were obtained in 3 animals (vibrissae in two, eye closure in two, and head in one).

Area I:—One animal gave inconstant reactions of vibrissae and fore leg.

Area J:—Vibrissae movements were secured in one instance.

Medial Surface:—This was explored in 4 animals. Two yielded movements of vibrissae and fore limb, a third, of the vibrissae alone, while in the fourth this region was unresponsive. In this fourth animal the medial surface of the left hemisphere was completely stimulated following careful removal of the right hemisphere and cutting of the falx cerebri. The responsive area in all three animals was confined to the more rostral portion of the medial surface, chiefly adjacent to area C.

It thus is apparent that the regularly responsive cortex logically can be roughly divided into 4 parts, each of about like extent. The most rostral part, along the middle of the frontal pole (area A) is concerned practically exclusively with the face; the second portion, occupying the top of the frontal pole (area B), likewise controls the face, but the fore limb is beginning to be represented; the third region, along the rostral portion of the crest (area C) is largely a fore limb area, but the facial representation still is well evident; and the fourth part (area D), just behind the preceding, seems to be more particularly concerned with the fore limb.

The vibrissae movements following cortical stimulation were predominantly bilateral, although occasional contralateral, or even ipsilateral, responses were noted. Closure of the eye, clearly involving m. orbicularis oculi, always was restricted to the contralateral side. No other reactions involving the ocular apparatus were observed. Head movements regularly were of the nature of a contralateral bending, although ventral flexion occurred in one instance. Fore limb reactions were either of an isolated character, confined to a single segment of the limb, or, more commonly, involved two or more segments. Of the isolated movements, those involving the more proximal portions of the extremity, especially the upper arm, were the most common; indeed, isolated reactions of wrist and of fingers each were recorded but once. Perhaps the most

typical movements were those involving (1) upper arm protraction with an accompanying forearm flexion (or supination, sometimes both), and (2) upper arm protraction, forearm flexion, and rhythmic clawing of the fingers. In the latter movement, extension of the wrist occasionally was included, so that at times the entire extremity was involved in the response. In such instances the reaction produced was strikingly suggestive of feeding movements as exhibited by the normal animal.

Protraction was by far the most common movement exhibited by the upper arm, but retraction, abduction and adduction all occasionally were noted. Flexion was the most frequent response of the fore arm, supination occurred at times, but pronation was rare; extension of this segment never was seen. The only movement shown by the wrist was one of extension. The fingers almost invariably reacted with a rhythmic clawing or grasping movement, simple extension being noted on but one occasion. At times the pollex was not involved.

The fore limb responses to cortical stimulation usually were limited entirely to the contralateral extremity, yet bilateral reactions by no means were rare. The ipsilateral movement almost invariably was similar to the contralateral reaction. It customarily, however, was simpler and weaker than the contralateral, and in some circumstances disappeared upon repetition of the stimulus. Completely ipsilateral responses were extremely rare. It by no means is improbable that these ipsilateral responses were the result of excitation of extrapyramidal pathways.

As previously noted, hind limbs and tail, in my experience, are not represented in the motor cortex of *Dipodomys*. In one hemisphere of one animal, however, under extremely light anaesthesia, retraction of the contralateral hind leg was secured with a current of 1.5 volts from points in areas D, E and F. Yet these reactions are open to grave suspicion, inasmuch as they were repeated without stimulus while the animal was emerging from the anaesthesia. They could not be duplicated by stimulation unless the anaesthesia was extremely light. The cortex of this animal then was removed and the underlying internal capsule of each side stimulated directly. Resultant reactions of the animal involved face and fore limbs, but neither hind limb nor tail. Similar stimulation of the internal capsule was performed on 2 other animals (3 hemispheres), with quite comparable results. Furthermore, stimulation of the cut surface of the cerebral peduncles in two animals (and hence presumably of the corticospinal fibres) produced only facial and fore limb movements. It seems logical, therefore, to conclude that electrically stimulable areas for hind legs or tail do not exist, at least regularly, in the cerebral cortex of *Dipodomys agilis simulans*.

Cortical Cytoarchitecture.—The histological structure of the cerebral cortex was studied in two specimens of *Dipodomys*, with a view toward comparing the location and extent of the cytoarchitectural "motor cortex" with that of the electrically excitable areas. The brains, preserved in 10 per cent formalin, were sectioned serially at a thickness of 10 micra and stained with thionin. As is well-known, the brains of rodents are characterized by their lack of structural differentiation within the cortex, this being an indication of their primitive status. To quote Herrick (1926) respecting this condition: "All (investigators) agree that in these lowly forms the boundaries between the various areas are indefinite and that the structural features by which the areas are distinguished are far less well defined than in higher brains." Notwithstanding, a "motor area," with the general characteristics of Brodmann's (1909) areas 4 and 6, can be recognized in *Dipodomys*, its location being that of the chief excitable regions. This area begins somewhat above the rhinal fissure and extends upward along the frontal pole, being carried backward as an arc along the superior surface of the hemisphere, for about two-fifths of its length as seen in projection from above. It does not appear to extend over upon the medial surface of the hemisphere, but begins at about the extreme medial edge of the crest and continues laterally for a distance

of some 2 mm. In one of the brains it coincides quite closely with the stimulable areas A, B, C and D, or, in other words, with those regions from which responses regularly were secured. In the second example its caudal limit just fails to reach that of D.

Stimulation of the Basal Ganglia (and Tegmentum).—The hind limbs (and tail) exhibit such locomotor specializations, however, that one would expect to find some encephalic mechanism for their control. An attempt has been made to locate this "center." In one animal the cortex was removed and the internal capsule and surface of the corpus striatum were stimulated as noted above. Following this procedure, Dr. Howard A. Howe, using a unipolar needle electrode, insulated except at its extreme tip, very kindly stimulated the diencephalic region of the forebrain. The electrode successively was thrust into the thalamus of each side, aiming for the subthalamus, and the current applied. At 2 volts—or even less—there was produced a regular response of the fore limbs (chiefly protraction), movements of the head (usually a contralateral bending), and at times some reactions of the vibrissae. Most striking, however, was a constantly associated movement of the ipsilateral hind limb, involving strong dorsiflexion of the foot and lesser protraction of the thigh, accompanied by a powerful bending of the tail to the ipsilateral side. These hind leg and tail movements were secured repeatedly from each half of the diencephalon. The brain then was preserved in a solution of 10 per cent formalin, and subsequently sectioned at a thickness of 10 micra and stained with thionin. This material has been generously studied by Doctor Howe, who reports that the electrode penetrated to the level of the subthalamus on each side. In another animal (on one side), following removal of the cortex, I stimulated electrically the diencephalon (more exact location being unknown), using an ordinary unipolar electrode, with quite similar results. At a current of 1.25 volts, there was produced a definite reaction of the ipsilateral hind limb (protraction of thigh and dorsiflexion of foot), together with ipsilateral bending (especially of the distal three-fourths) of the tail; this was accompanied by some movements of the fore limbs and occasionally of the head. An additional specimen, however, yielded no reactions upon similar treatment; in this animal but one side of the cerebrum was investigated. Yet electrical stimulation of the mesencephalic tegmentum in this same rat produced hind leg and tail movements resembling those elicited from the diencephalon in the other two animals (from the right side of the tegmentum there was secured an accompanying retraction of the contralateral thigh, but not from the left half of the tegmentum). These hind leg and tail movements elicited from the diencephalon (and tegmentum) are identical with those exhibited in one phase of bipedal leaping by the living animal.

Decerebration.—Two of the kangaroo rats were decerebrated following stimulation of the forebrain. The first of these was in poor condition and died shortly after decerebration, without development of any noteworthy rigidity. The second individual, however, yielded results that appear significant. Decerebration was performed through the opening in the vault of the skull by means of a blunt spatula, and anaesthesia promptly discontinued. Subsequent examination of the preserved brain showed that the transection was oblique, passing between the superior and inferior colliculi on the right side, and through the rostral portion of the superior colliculus on the left; the exit ventrally was at the rostral border of the pons. Bleeding was controlled easily with cotton pledgets packed loosely in the cranial cavity. The body temperature of the decerebrate animal was maintained by the use of electric lamps. Under these conditions the animal lived for about 3 hours following the decerebration. Respiration was satisfactory until shortly before death. After recovery from the initial shock following decerebration, the animal exhibited periods of rigidity in which the attitude of the limbs was that assumed in the bipedal posture during life. In the hind limbs there was a general physiological extension, with thigh somewhat retracted, knee imperfectly extended, and foot held

tonically at a right angle to the leg. There was considerable resistance to passive dorsiflexion of the foot. The tail was curved markedly in a dorsal direction. The fore limbs were held in a general attitude of flexion, with upper arm slightly protracted and forearm markedly flexed, the elbow being the most rigid joint in the entire limb. No marked dorsal bending of either head or trunk was noted. The rigidity could well be appreciated by attempting passive movement of the extremities. These periods of rigidity were followed by intervals of relaxation or of progressive movements during which the limbs appeared regularly to be moved diagonally. A species of righting reflexes was present in the decerebrate *Dipodomys*. These were quite apparent during the resting or running periods, and could be produced by extending the hind leg or pinching the distal segments of the limb; the animal then turned over to the side so stimulated. Manipulation of the fore limbs, however, produced no such reaction.

Discussion and Conclusions.—It may be concluded, on the basis of electrical stimulation under light ether anaesthesia, that the cerebral motor cortex of *Dipodomys* is not concerned with movements of progression. Hind limbs and tail appear not to be represented here; in this detail *Dipodomys* agrees with certain other mammals possessing brains of rather primitive organization (cf. Huber, 1934). In other rodents, such as porcupine (Langworthy and Richter, 1933), guinea-pig and white rat (see Huber), the hind limbs possess clear cortical representation. When the white rat is subjected to the same experimental treatment as that described for *Dipodomys*, discrete movements of tail and hind limb, and even of individual toes, can be elicited. The facial muscles of *Dipodomys*, especially those concerned with movements of the vibrissae, are well represented in the cortex. Fore limb reactions following stimulation essentially are those exhibited by the living animal during feeding.

It is interesting to note that the "motor" cortex of the kangaroo rat is not associated with progression, but with movements of a very different nature, pertaining essentially to manual inspection and manipulation of objects. Furthermore, it seems significant that even in such a primitive animal these actions, on occasion, can be woven into rather complex patterns. In this respect *Dipodomys*, however, by no means is unique; for even in the monotreme *Ornithorhynchus*, in which a motor cortex would appear to be in its incipiency, patterned movements, suggestive of the animal's actions when digging a burrow, have been elicited by cortical stimulation (see Martin, 1898).

The most regularly responsive cortical areas of *Dipodomys agilis simulans* have been labelled A, B, C and D. They may be regarded as constituting the true motor cortex of this animal. The alignment of the parts of the body represented therein agrees with that seen in certain other primitive mammals, such as the bat and hedgehog (cf. Huber, 1934). These four regions correspond rather accurately in location and general extent to the motor type of cortex as determined by me histologically. This "motor area," furthermore, seems to coincide quite closely with area *f* of *Dipodomys merriami nitratoides* as charted by Fortuyn (1914) from cytoarchitectural studies. According to this investigator, his area *f*—at least in the rabbit—corresponds to Brodmann's areas 4, 6 and 4 + 6. Both physiological and morphological evidence thus indicates that this area is a motor region. The lower portion of my area A apparently does not encroach upon Fortuyn's area *g*, which in the rabbit probably is homologous to Brodmann's area 8. The responsive region located on the medial aspect of the hemisphere corresponds to those portions of Fortuyn's areas *f* and *n* that extend over onto this surface. Fortuyn stressed the fact that his area *n*, which is located just behind *f*, contained extraordinarily large infragranular pyramids, which indeed were the largest in the entire cortex of the rodents that he studied. This circumstance suggests a motor function. In some of my specimens, at least, stimulable area D would seem to extend backward beyond the caudal limits of the true motor type of cortex, and hence into the most rostral part of Fortuyn's area *n*. According to my interpretation, how-

ever, this region is not "motor" in structure, and furthermore, its infragranular pyramids do not appear to be especially large.

The minimal current necessary to elicit a response from the motor cortex of *Dipodomys* is calculated to be about 0.0003 ampere. This is appreciably less than that required for similar stimulation, for example, of the rhesus monkey. This fact is not in agreement with the suggestion advanced by Huber (1934) that mammals possessing primitively organized brains require a stronger current to produce responses than do those with more complex cortices. Indeed, it is more likely that the chief factor is related to actual thickness of the outer layers of cortex (cf. also Boynton and Hines, 1933). The entire cortex is very thin in *Dipodomys*.

In the diencephalon—possibly in the subthalamus—there is a "center" concerned with progressive movements, apparently fundamentally of the bipedal sort. The concept of a diencephalic "center" for progression is by no means a new one (see the review by Langworthy, 1928; and Hinsey, Ranson and McNattin, 1930). That the subthalamus may be the particular region concerned is suggested by the predominantly motor character of its cells (see Howe, 1933). Stimulation of the tegmentum in one of my animals produced hind limb and tail movements resembling those produced by excitation of the diencephalon. This is similar to the results obtained by Weed and Langworthy (1925) following stimulation of the tegmentum in a decerebrate opossum, except that in the kangaroo rat the fore limbs were not involved in the response.

The group or groups of cells regulating the more primitive type of diagonal progression in the kangaroo rat seem to be located somewhere in the hindbrain, as evidenced by their continuing function in opposition to the postural nervous mechanism subsequent to decerebration. Similar alternation of rigidity and progressive movements following decerebration occurs also in the adult opossum (Weed and Langworthy, 1925) and in young kittens (Weed, 1917). The decerebrate rigidity, as noted in a single specimen of *Dipodomys*, involves extension of the hind limbs and flexion of the fore limbs as seen in the resting posture. The posture of the forelimbs following decerebration is in contrast to that occurring in the ordinary laboratory mammals, such as cat and dog, in that there is flexor, rather than extensor, rigidity.

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A STUDY OF THE WINTER ACTIVITIES OF THE MINK

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The literature on wild carnivores contributes little information regarding the activities of the mink. Seton (1929) presented a general account of the animal, and several trade journals have dealt with the practical phases of mink ranching, but other published information is of a fragmentary nature.

The mink (*Mustela vison mink*) has remained fairly common in southern Michigan in spite of intensive trapping and hunting and of reductions in the extent of its preferred habitats. It contributes in no small way to the livelihood of people in rural sections. Thus field research on the mink is important both because of the economic values involved, and because of the definite lack of published information.

The preliminary study presented in the following paper was carried on in Washtenaw County, Michigan, during the months of December, 1934, and January, February, and March, 1935. The report has been submitted in partial fulfillment of the requirements for the Master's degree at the School of Forestry and Conservation, University of Michigan, June, 1935. Extensive observations were made in Dexter and Lyndon townships, and along the Huron River, while more intensive studies were made along Fleming Creek in Ann Arbor Township. The greater part of the field work was done following snowfalls and the observations were mostly on tracks.

Professor H. M. Wight, through his continued help and stimulating criticism, contributed greatly to the progress made in the study. Acknowledgments for guidance are due to Professors S. A. Graham, E. C. O'Roke, and Neil Hosley, Pack Fellow in the School of Forestry and Conservation, University of Michigan. Coöperation with fellow graduate students added greatly to the pleasure derived from the work. For aid in identifications I am indebted to Dr. Seth Benson.

The first step in wild life management is the determination of the breeding population on the area under consideration. Due to the wariness, low population density, and noctural habits of the mink, trapping or direct observation is not applicable to the mink, and den or feces counts would be very difficult to obtain. This study soon showed that tracking in snow might give many valuable data, and suggested the feasibility of attempting to develop a census method by tracking during the late winter months.

It is apparent that, in order to develop a method of sampling the population of a given area, it is necessary first to determine the various types of activities demonstrated by individuals, when and where these activities take place, and how they may be measured. In developing the census method discussed later, many interrelated factors were considered.

It soon became evident from the observation of tracks in the field that there were marked differences between the activities of two size classes of minks. This suggested the possibility of determining the sex of mink in the field by their tracks. In addition, consideration was given to the extent of winter movements by individuals; to the use of dens during the winter; to the presence or absence of routine in winter movements when both time and place were considered; to the effects of meteorological conditions on these movements; to the time and nature of the movements; to the mating behavior; and, finally, to the cover type preferences.

Field Identification of Sex.—It is a well-known fact that male and female mink differ in size. Anthony (1929), stated that "females are noticeably smaller than males", and other writers have made similar statements. The tracks of the hind feet of 35 individual mink were measured. This was done on fresh snow where the animals had been walking on level ground. These measurements represented the distance from the tip of the toe-nail to the back of the impression left by the rear or main pad. The results are presented in figure 1. Examination of these figures indicated that there were two distinct groups of measurements, and a calculation based on the "standard error of the difference" indicates that the significance of the difference between the two groups is valid, since treatment of two "universes" gave a normal deviate of more than three, which indicates a significant difference.

That these two groups represent the different sexes was indicated by other data, obtained from various sources. The measurements of the hind feet, from toe-nail to rear pad, of 6 male mink carcasses obtained during the period of the study, varied from 3.5 to 5.0 cm. It is to be noted that this checks with table 1. The recorded *total lengths* of the hind feet of several study skins of adult mink in the University of Michigan Museum, showed that the feet of females were less than 5.2 cm., while those of males all were more than 5.9 cm. This information was obtained through the courtesy of Dr. L. R. Dice. Mr. Harry Saxton, of Jamestown, New York, kindly assisted by measuring at his ranch, in fresh snow, the lengths of the tracks of 10 captive adult minks of known sex. The tracks of 5 females all were less than 4.0, while those of 5 males all were more than 4.5 cm. in length.

Ames (1930) has presented figures on the total live weights of pen-raised mink as in table 1. These will be seen to indicate material differences in the weights of the sexes.

The possibility of confusing immature males with mature females intrudes at this

point. The basic data, supplied by the Biological Survey, used in preparing Wild Life Management and Research Leaflet BS-60, shows that the weights of 8 male mink kits at 8 months of age ranged from 1.71 to 1.81 while 8 females ranged from 1.37 to 1.61 pounds. The means were 2.22 and 1.47 respectively. A calculation, similar to that used in analyzing figure 1, indicates a significant difference between the two groups.

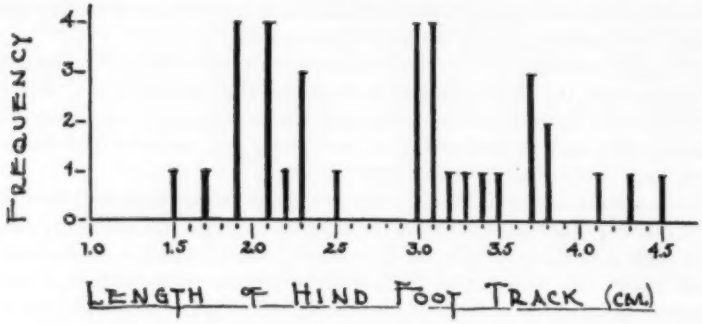

FIG. 1. Graph showing frequency of mink tracks by size. Totals: 2.75 cm. or over —20 individuals; 2.75 cm. or less—15 individuals.

TABLE 1

Total live weights of pen-raised Alaskan mink

NUMBER OF ANIMAL	AGE	SEX	DATE	WEIGHT
				grams
88D	1	♀	3–19	820
31D	4	♀	3–23	838
115D	1	♀	4–1	1200
12D	2	♀	3–26	890
9D	2	♀	3–25	790
4D	2	♀	3–27	810
25D	?	♂	3–16	2310
29D	?	♂	3–16	1680
33D	?	♂	3–16	2010
39D	?	♂	3–16	2200
18D	?	♂	3–16	2150

Data on the study skins of immature mink in the Michigan Museums indicate that this is true in the wild also.

On the basis of the above information it seems reasonable to assume that the sexes of mink may be determined by measuring their tracks in fresh snow in late winter. For southern Michigan the following scale is proposed: Hind foot track less than 2.75 cm.—female; or greater than 2.76 cm.—male. It is probable that in nature, giants and runts may occur in both sexes. Recognizing this fact, the above is a preliminary presentation subject to further study. Apparent differences that may be encountered

undoubtedly are due to different types of measurements and different subspecies. It will be seen that in each comparison there is a significant difference between the sexes.

Since the activities of the two sexes of mink seem to vary, as discussed later, sex determination based on track measurements may further be verified by a study of complete track records.

Extent of Winter Movements.—Track observations indicate several important differences in the behavior of the sexes. Of especial interest is this difference in the extent of the winter movements of individuals. Table 3 and figure 3 present tabular and graphic records of the movements by individuals. The map embraces an area of nearly one square mile on Fleming Creek and the routes depicted are those recorded on two significant mornings. Table 3 summarizes certain field observations, both on Fleming Creek and in Dexter Township. It will be noted that females tend to remain within a restricted area, and in the cases studied the extent of their territory did not exceed 20 acres. The males, however, covered a much larger territory; in fact too large to be estimated with accuracy. Trappers, in my conversations with them, made statements which substantiate these conclusions.

Use of Dens.—The study of Fleming Creek indicated that there also are differences in the use of dens, in accordance with sex, seemingly correlated with differences in the extent of movements. Sixteen dens, suitable for mink, were found within the area. These all were under the roots of trees on the banks of the creek, and appeared to have been old muskrat dens. Each had one or more entrances just above the normal water level of the stream, with upward-sloping tunnels between tree roots, and one or two surface openings, with tunnels that were nearly vertical for 18 inches and then turned horizontally. These openings were at a distance of about 5 feet from the bank. Pictures of the openings of several dens are presented in figure 2. Observation indicated that each female used only two den-sites during the period of study. Female no. 1 used den no. 1 eight times, once sharing it with a male. On three occasions she was tracked from den no. 3 and returned to den no. 1; at these times a male had been in den no. 1 while she was in den no. 3, but he failed to return. After two snows the female was tracked both in and out of den no. 3. Once, when a male sought refuge with her in den no. 1, the tracks showed that he had left immediately.

Female no. 2 used den no. 5 in January, and then changed to no. 7 about the first of February. The distance between the dens was 50 yards. On two occasions she shared no. 7 with a male. Both females used either the upper or the lower entrances, although they tended to leave more frequently by the lower entrances.

It was evident from the tracks that the males did not use the same dens repeatedly. While moving along the stream they investigated every den that they encountered, usually entering but sometimes merely circling the openings.

Routine.—Tracking records do not disclose the repeated following of definite routes by individual mink. The two females on Fleming Creek were as likely to move away from the creek, on either side, as to follow it. Both crossed the creek and each is known to have killed, unaided, a muskrat in the water. The tracks usually were found along small paths rather than through or within thick clumps of brush or sedge.

The males tended to follow the stream along one or the other of the two cow paths that paralleled it, but exhibited no preference for either side. A comparison of the data on the distances travelled, with the times of snow fall, indicated that the animals spent a large proportion of the time within the dens. Several observations point to the fact that both sexes most frequently move about in the winter during the hours of dawn and dusk, but that they also may be active near the middle of the day (cf. observations nos. 1, 3, 4, 5, 6, 8 and 9, table 3).

Effect of Temperature on Activity.—Table 3 presents certain pertinent observations with respect to activity. During the study two periods occurred when temperatures fell

TABLE 2

Pertinent observations

NUMBER	DATE	PLACE	TEMPERATURES		SNOW CONDITIONS	TIME	COVER TYPE	OBSERVATION	REMARKS
			Maximum	Minimum					
1	12–30–34	Fleming Creek	31.2	25.2	2.6″ Fresh	5:10 P.M.	C_1	Female No. 1 left den No. 1 to travel upstream 200 yards then back to den	Snowfall stopped at 7:00 A.M.
2	12–27–34	Sec. 15 Lyndon Twp.	23.2	−2.0	3″ Old			No fresh mink tracks in six miles line	
3	1–13–35	Mud Lake	37.0	22.5	½″ Fresh	11:10 A.M.	D_5	3.7 cm. track on ice. Temp. 31°	Snowing slightly so as to obscure tracks in few minutes.
4	1–13–35	Mud Lake	37.0	22.5	½″ Fresh	1:20 P.M.	D_9	3.7 cm. and 2.1 cm. track in snow under trees	50′ from obs. No. 3.
5	1–14–35	Fleming Creek	33.2	20.8	1″ Fresh	7:56 A.M.	C_1	Female No. 1 recently entered den No. 1	Later a male (3.0) crossed my tracks and entered den N No. 1 but left immediately.
6	2– 4–35	Huron River	28.1	18.0	Trace	8:20 A.M.	A_7H_2O	Female (2.5) and male (3.7) cm. tracks fresh	Snowing lightly.
7	2– 7–35	Dexter Twp.	25.2	5.0	2″ Old	—	—	Of 15 mink tracks found in covering 20 linear miles only 6, which were in sheltered spots, could be measured: none were fresh	
8	3– 8–35	Dexter Twp.	28.0	16.0	3″ Fresh	11:20 A.M.	B_4	Four fresh mink tracks (2♂ and 2♀)	Snow had stopped falling at about midnight.
9	4–11–35	Fleming Creek			Raining	5:40 P.M.	C_1	Small mink seen. Moved 20–30 feet then back to den. Temp. 47°F.	

TABLE 3

Extent of mink movements

DATE	SIZE TRACKS	PROBABLE SEX	TYPES CROSSED	AREA COVERED	GREATEST DISTANCE FROM DEN	USE OF DEN	OTHER SEX PRESENT	REMARKS
	cm.							
1-14-35	2.1	♀	C_1–B_6	5 A	6 chains	Returned to same den	Yes	
1-14-35	3.5	♂	C_1–B_6	120 A		Tried to seek refuge in den with ♀	Yes	Moved across Fleming Creek area
1-14-35	1.5	♀	C_1–3	3 A	5 chains	Left den No. 5	No	Lost tracks
1-17-35	2.1	♀	C_1–3_6	3 A	8 chains	Returned to same den	No	
2-23-35	2.1	♀	C_1	1 A	2 chains	Returned to same den	No	
2-23-35	1.5	♀	C_1–B_6	1 A	3 chains	Returned to same den	No	
2-24-35	2.1	♀	C_1	1 A	2 chains	Returned to same den	No	Killed mouse
2-24-35	1.5	♀	C_1	1 A	3 chains	Returned to same den	Yes	
2-24-35	3.5	♂	C_1	120 A				Moved across Fleming Creek area
3- 8-35	4.1	♂	B_4	120 A	¾ mile		Yes	In Four Mile Lake marshes
3- 8-35	3.0	♂	B_4	80 A	½ mile		Yes	In Four Mile Lake marshes
In addition, two female tracks were lost due to thin ice on the marshes								
3- 9-35	3.4	♂	B_4–A_7–D_7	Covered	3 miles in distance		No	From Sec. 20 to Sec. 33
3- 9-35	2.1	♀	B_4–A_4–C_1	20 A	20 chains	Returned to same den	No	Displaying sliding habit

below 10 degrees F. at a time when tracking conditions were good. Observations given in nos. 2 and 7, table 2, show that on these two days no fresh mink tracks were found. Fresh tracks were encountered on all other field trips. These observations indicate that mink are inactive during periods of low temperatures following snowfalls.

Mating Behavior.—The mating behavior of the males appears to account, in part at least, for their extended movements. This has been indicated in the previous discussion on the use of dens and territory. Males were known to have shared a den with a female on 3 occasions. Twice, at an interval of 29 days, the tracks of female no. 1 and a male, track length 3.5 cm., indicated attempts to copulate. On the night of the first observation this male was known to have run with the two females within the area. Four different males were known to have been in this area during the study at times when tracking was possible. Observations nos. 1, 2, 10 and 11, table 3, show that males were known to be running with females at least from January 14 to March 8, a period of nearly 2 months.

Saxton (1931), in breeding-records for his ranch-raised mink, indicated that one male mated 9 times during the period from February 28 to March 25. These matings were with 6 females. One female was mated 4 times with 2 males at intervals of 7, 9, and 11 days during the same period. W. D. Carpenter (1933) presented a wealth of material on this subject. He recorded males successfully mating with as many as 6 females, although the average mating ratio maintained was 1:3. Eighty per cent of the matings occurred during the two weeks following February 28, and 90 per cent of the litters were born within a period of similar length, beginning 52 days later. Several females were mated successfully 3 times, while a number bore litters even though they had been mated only once. These notes indicate a marked activity of the males during the mating season, and the extended movements of the males observed during this study, and reported by others, may be explained in part by a tendency pronouncedly promiscuous.

Cover-Type Preferences.—The cover-type preferences of mink during the late winter were studied with the intent of being able to predict where mink and mink tracks might be found. Fellow graduate students in wild life management contributed to the records presented. The observations are classified on the basis of a cover-type system developed by Wight (1934). In this system there are 55 types, presented as developing through 6 successional series, 4 being hydrarchs and 2 xerarchs.

Sixty-six observations on mink tracks were made, and were recorded as to type where first they were encountered. Fifty-eight of the observations were in types of hydrophytic successions; of these, 43 were in bushy and timbered types, while 15 were in "sedge" and "cat-tail" types. The observations recorded in xerophytic successions were all within 100 feet of the Huron River. Records of the tracks of mink on Fleming Creek show that by far the majority of the movements of these animals were in the "brushy" and "sedge" types, and rarely were more than 30 feet from them.

The evidence obtained during the study indicated the following tentative conclusions:

1. The sex of mink may be determined by the length of the tracks of the hind feet measured in fresh snow during late winter.
2. The winter territory of female mink tends to be restricted to an area of approximately 20 acres.
3. The winter territory of the males is much more extensive.
4. Mink display promiscuous mating behavior.
5. Late in the winter the movements of mink largely are in the hydrophytic cover types.
6. Mink tend to be inactive during cold periods following precipitation.

Work in the field and in preparing these data has convinced me that it is possible

FIG. 2. Upper left, upper entrance; and lower left, lower entrance, of den no. 3. Upper right, upper entrance; and lower right, lower entrance, of den no. 15.

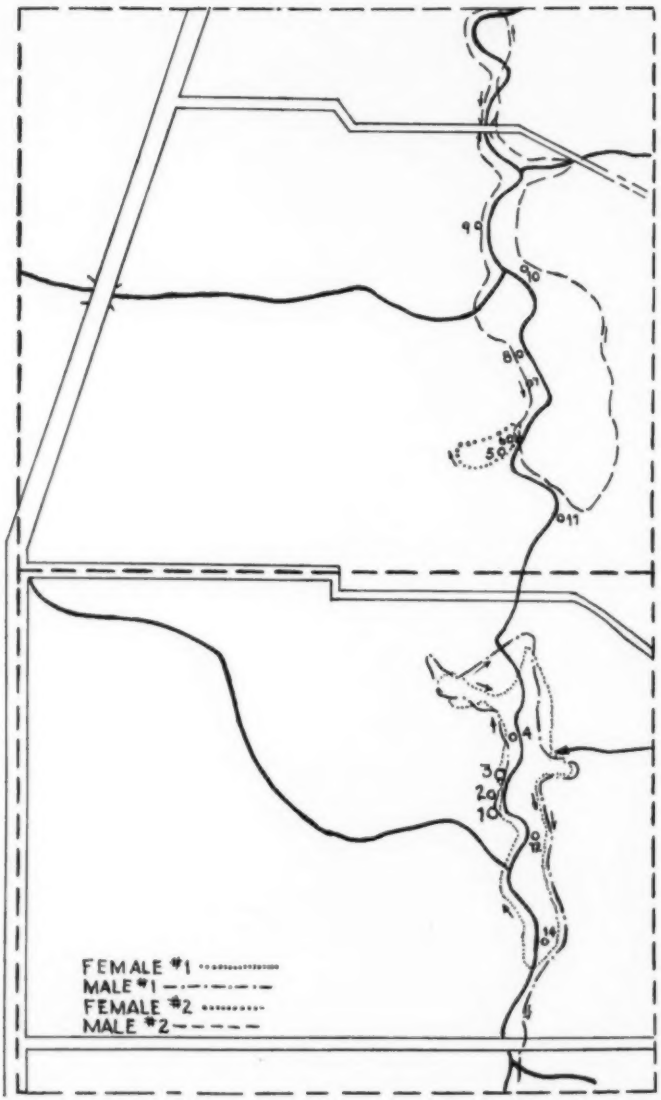

FIG. 3. Fleming Creek mink tracks, February 17, 1935

to outline a census method for the mink at this time. There are, however, several underlying points to be mentioned.

A cover-type map, preferably one based on ecological concepts, is most essential to the census. Such a map increases efficiency and accuracy, both in the field and in interpreting the data in the office. Field efficiency is particularly desirable in view of the fact that during any one winter there may be only a few occasions when tracking is at its best.

Since mink display promiscuous mating behavior, a census of the females, with qualitative information on the males, will give the essential and usable data.

With these points in mind, a preliminary census method is proposed for the purpose of stimulating further work:

1. Censuses can best be made in the late winter immediately following "wet" snowfalls from 1 to 4 inches in depth, when temperatures remain above 15 F. following the snowfall.

2. Lines should be run at random across all the hydrophytic types of the area to be sampled.

3. Mink tracks should be recorded as to length, type where found, and direction in which the animals moved.

4. In southern Michigan tracks less than 2.75 cm. in length should be recorded as those of females, and followed until the territory of each female is determined. Tracks of more than 2.76 cm. should be recorded as those of males and noted as crossed.

5. The data should be compiled on the basis of the samples, and then applied to the area for which the total population is desired.

Using this method one man easily may census two sections in a day. Office work consists of interpreting the data on the basis of the female territories found in the unit area, and then applying this to the total area.

The field work of the writer and two assistants on February 7, 1935, may be used to illustrate this method. A nearly 100 per cent survey of the hydrophytic types on three sections, or square miles, in Dexter Township was made in 10 man-hours, or one section per three and one-third man-hours. On section 25 the tracks of 2 females (1.9 and 1.3 cm.) were found one-half mile apart. The tracks of one male (3.1 cm.) were found with those of the smaller female. Section 31 contained the tracks of one female (2.1 cm.) and one male (3.1 cm.) in the center of the section. On section 6 the tracks of a male (3.1 cm.) were crossed 3 times, while those of a female were found with the male's for a distance of several hundred yards, after which she had doubled back toward the point where the tracks first were found. On section 33, March 8, the tracks of 2 males (3.0 and 4.1 cm.) and 2 females (1.9 and 2.3 cm.) were found. These tracks all were encountered in the hydrophytic types of the marsh and swamp groups. These sections may be considered as representative of the township.

The data may be interpreted as indicating a population of 1.5 females per section, or 54 for the township, with a 1:1 sex ratio. The study of Fleming Creek showed that there were 2 females in an equal area, and that 4 males traveled over the area during the winter. Thus the population in this area consisted of 2 females and at least 2 males. It must be borne in mind that these populations are those following a heavy trapping and hunting season.

This census method is offered with the thought of attempting to correlate a method biologically sound and one that is statistically correct: in other words, by discovering the number of individuals in "sample plots" through using the concept of individual territories.

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THE MARMOTS OF COLORADO

By Edward R. Warren

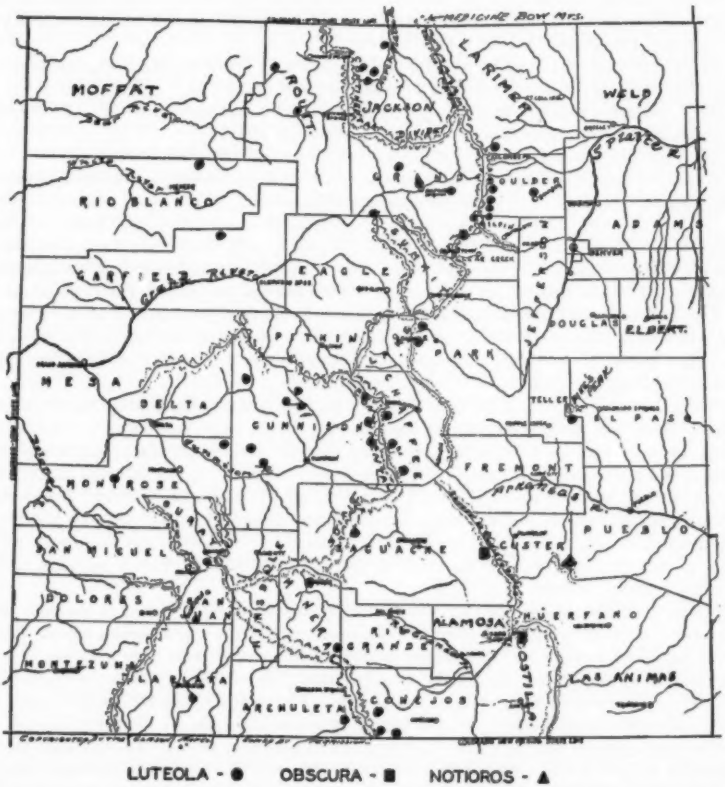
During the past few years I have had occasion to study the marmots of Colorado, and have reached the conclusions stated in the following pages. In addition to the considerable number of specimens in my own collection, I have had the loan of specimens from the following institutions, and wish to express my appreciation for the courtesies thus extended to me: The Colorado Museum of Natural History, Denver, J. D. Figgins, Director; the museum of the University of Colorado, Boulder, Hugo Rodeck, Curator; the American Museum of Natural History, New York, through H. E. Anthony, Curator of Mammals. Ridgway's Nomenclature of Colors was used in making the color comparisons of the specimens.

Five subspecies of marmots have been attributed to Colorado, as follows: *Marmota flaviventris luteola* Howell; *M. f. warreni* Howell; *M. f. campioni* Figgins; *M. f. obscura* Howell; *M. f. notioros* Warren.

At the beginning of this study I had no doubt that *luteola* and *warreni* were subspecifically distinct, and my purpose in collecting was to determine the distribution of the two forms. As specimens accumulated from different parts of the state I began to suspect the validity of *warreni*, for there seemed to be no well-defined characters by which it may be recognized; and this appeared also to be the case with *campioni*. These last two subspecies, therefore, become synonyms of *luteola*, which has priority.

Marmota flaviventris luteola. Park Marmot

Marmota flaviventer luteola Howell, Proc. Biol. Soc. Wash., vol. 27, p. 15, 1914. Type locality: Woods Post Office, Medicine Bow Mountains, Wyoming (altitude about 7,000 feet).



Map of portion of Colorado showing distribution of the different subspecies of marmots.

Marmota flaviventer warreni Howell, Proc. Biol. Soc. Wash., vol. 27, p. 16, 1914. Type locality: "Smith trail," 2 miles west of Crested Butte, Gunnison County, Colorado, at about 10,000 feet.

Marmota flaviventris campioni Figgins, Proc. Biol. Soc. Wash., vol. 28, pp. 147–148. 1915. Type locality: Detached range between the "North Fork" and the North Platte River, 8 miles northwest of Higho Post Office, Jackson County, Colorado.

Of the above named forms I have examined 22 specimens attributed to *luteola* in my own collection, and 12 in other collections, a total of 34. Of those supposed to be *warreni* I have 66 specimens, including juveniles, in my collection, and have examined 12 in other collections, a total of 78. Of *campioni* I have examined 4 specimens, including the type, a grand total of 116 specimens, nearly all accompanied by skulls.

Measurements.—Adults of all these forms vary much in size, and averages of the body measurements are too misleading really to be useful; therefore I give in millimetres the extremes of both sexes as follows:

M. f. luteola, total length: ♂, 554–655, ♀, 523–677, tail vertebrae, ♂, 141–220, ♀, 137–220, hind foot, ♂, 80–88, ♀, 77–85, ear, ♂ 29 (only ♂) 25–28.

M. f. warreni, total length, ♂, 555–665, ♀, 502–670, tail vertebrae, ♂, 152–215, ♀, 140–228, hind foot, ♂, 75–92, ♂, 72–82, ear, ♀ 28–39, ♀, 24–31.

M. f. campioni, total length, ♂, 670, tail vertebrae, ♂, 180, hind foot, ♂, 83.

Color.—There is great variability in the color of these animals. Individual variability plays some part in this, but the season and the condition has much more to do with it. When first the animals emerge from hibernation they are somewhat faded in color, and the fading increases until late in June. Early in July the moult begins, in males sooner than in females. This change of pelage progresses with individual irregularity, until by the last of August or early part of September the new coat is fully acquired.

In studying the color I spread on a long bench about 50 skins which, from geographical considerations, I had called *warreni*, the lightest colored at the left end of the line and the darkest at the right. The gradation in color was practically uniform from one end of the line to the other.

The palest skin, my no. 4320 from Mesa Creek, Black Mesa, Gunnison County, taken July 4, 1933, was tawny olive above, and several others were very close to this color. Then, as one proceeded along the line, they became darker, through buckthorn- and cinnamon-brown, with some nearer antique brown. Some of the animals that had begun the moult had the new coat near Mars brown; others, however, were nearer Prout's or mummy brown, which became more predominant as one progressed along the row. Then seal brown and blackish brown began to show. My no. 4270 has so many white-tipped hairs that the underlying color is difficult to determine, but it appears to be nearest mummy brown.

The darkest specimens are the well grown young of the year, taken in August, and their color all over comes very close to light seal brown, with white-tipped hairs. This great variation in the condition of the pelage renders description very difficult, if not impossible. The lightest colored tail is tawny olive, like the back of the specimen; the darkest, between mummy and light seal brown. The top of the head nearly always is darker than the back, varying from chestnut brown to blackish.

The markings on the head are very variable in all three forms. On the chin there always is a white area, sometimes quite small, but mostly rather extensive and sometimes pronouncedly so. Almost always there is white at the sides of the mouth, and a few white hairs between nose and eye, at times sufficiently extensive to form a pronounced band, either white or grizzled yellowish or brownish. Specimen no. 4360, from Illinois Creek, Taylor Park, taken September 3, has much white on the face, extending from above the nose to halfway between the eyes and ears. This is mingled somewhat with dark colored or blackish hairs. The type of *campioni* has a large, buffy whitish area on the face, from the top of the head between the eyes, down to the nose and around the sides of the head. The face of a topotype is somewhat similar. A skin from La Manga Pass, Conejos County, has a white area, 15 mm. wide, from above the nose to between the eyes, and extending 50 mm. across the face. The

white areas on each side of the mouth are quite extensive, but are not connected with the one above.

The underparts of the specimens are variable, from tawny olive to mummy brown, and the shade apparently has nothing to do with color of the dorsal surface, as a specimen with a light colored back may have the under parts quite dark, and *vice versa*.

Seventeen specimens which were attributed to *luteola* were compared with this series of *"warreni"* and could be matched with one or another of that series, but none was as light colored as the lightest of that group. A specimen from Pike's Peak, one-half mile below the summit, at about 13,760 feet, taken October 5, is identical dorsally with two from Illinois Creek, taken August 30 and September 7, respectively. Most of the tail of this specimen is dark, but there are some lighter colored hairs in the tip, which were not fully moulted. The facial markings are essentially the same as those of the skin taken September 7, and the under parts of all three are in close agreement, varying from tawny olive to between mummy brown and light seal brown. These three animals might have come from the same locality instead of from places 100 miles apart in a practically east-west direction.

Comparisons made with Howell's description of *luteola*, showed specimens of both forms agreeing closely in color with his description of the long hairs of the back; but the under fur varied, sometimes being warm buff and ochraceous buff as Howell gave it, but more often darker, buckthorn and antique brown, and occasionally quite dusky. This variability in the color of the under fur seems independent of the season, and apparently in itself is a variable character.

The cranial measurements are about the same for all forms. The extremes in condylo-basal length for *"warreni"* are: Males, 93.–75., females, 89.3–77.5; *luteola*: males, 91.2–75., females, 85.–72.5 mm. Zygomatic breadth in *"warreni"*: Males, 61.–49., females, 59.–50.; *luteola*, males, 60.5–50.5, females, 59.8–46.7 mm.

The averages of the cranial measurements of all my adult specimens, but omitting the apparently variable maxillary tooth row, are as follows:

AVERAGE OF MEASUREMENTS	CONDYLO-BASAL LENGTH	PALATAL LENGTH	POST-PALATAL LENGTH	LENGTH OF NASALS	ZYGOMATIC BREADTH	WIDTH ACROSS MASTOIDS	LEAST INTER-ORBITAL WIDTH	BREADTH ACROSS ROSTRUM
Number of specimens, *"warreni"*	49	52	50	53	52	49	55	53
Averages	83.2	45.5	36.2	35.9	55.1	41.1	18.7	16.7
Number of specimens of *luteola*	18	18	19	18	18	18	19	19
Averages	81.9	45.2	35.6	33.6	54.4	39.2	17.8	18
Average of all:								
Number of specimens	69	70	69	71	70	67	71	72
Averages	82.4	45.4	36	35.3	55	40.6	18.5	17.1

Note: The measurements of the type of *warreni* were taken from Howell.

As a check on the above averages, I averaged the percentage of each measurement as compared to condylo-basal length, with the following results:

SPECIMENS	CONDYLO-BASAL LENGTH	PALATAL LENGTH	POST-PALATAL LENGTH	LENGTH OF NASALS	ZYGOMATIC BREADTH	WIDTH ACROSS MASTOIDS	LEAST INTER-ORBITAL WIDTH	BREADTH ACROSS ROSTRUM
Average of 52 specimens of *warreni*	100	53.7	43.6	43.0	66.6	49.5	22.5	20.0
Average of 21 specimens of *luteola*	100	55.3	43.5	40.8	66.5	48.1	22.4	21.9
Average of 4 specimens of *campioni*	100	56.4	41.4	40.4	64.8	48.8	20.9	20.8
Combined averages of *warreni* and *luteola*	100	54.2	43.6	42.4	66.6	49.1	22.4	20.8

Note: The zygomatic breadth could be taken on but three of the specimens of *campioni*.

These figures show the close agreement of the proportions of the crania of these animals. The facts that no differentiation can be made between these forms on the basis of color, and that the averages of the cranial measurements vary but little from one another, appear to bear sufficient evidence that *warreni* and *campioni* are synonyms of *luteola*, which has priority in publication. As these animals have a practically continuous range from the type locality in Wyoming south through the mountains of Colorado, there seems to be no good reason why there should be more than one subspecies of marmot occupying this region. The animals occur even to the mountain tops, and cross freely from one side of a range to the other, and a divide, therefore, is no boundary line for them. I think that as a rule most of the Colorado marmots are found above 9,000 feet elevation.

On the accompanying map are shown the localities from which specimens have been examined. I have reports of marmots from various other places, especially north of the Pike's Peak region, but have omitted mapping them.

Certain specimens, not considered in the above discussion, merit especial mention. A melanistic individual in the Colorado Museum of Natural History, from Dixie Lake, Boulder County, is very handsome. The general color is a light seal brown, appearing almost black in contrast with the numerous white-tipped hairs. It is nearly the same color below.

There is a skin from Florida, La Plata County, in the collection of the American Museum of Natural History, that Howell labeled *obscura*, remarking that the color indicated intergradation with *warreni*. It is practically indistinguishable in color from my Wolf Creek Pass specimens from the San Juan Mountains on the Continental Divide.

Howell (1915) labeled as *obscura* certain specimens from Osier, in the collection of the Colorado Museum of Natural History. The San Juan Range, where Osier is situated, is close to the New Mexican boundary, and is approximately 60 miles west of the Sangre de Cristo Range. The wide Rio Grande Valley is between these two ranges, and on geographical grounds these marmots belong to "*warreni*" (=*luteola*) as do the others in the San Juan Range. There seem to be no marmot records from the New Mexican part of the San Juan Mountains, and all records for *obscura* are from the Sangre de Cristo Range.

Occasionally an individual marmot attains an unusual size. I have one in my collection, and have seen or heard of others. This one of mine, taken near Mirror Lake, Tin Cup, Gunnison County, measures: total length, 725; tail, 211; hind foot, 91; ear from notch, 31; condylo-basal length of skull, 95; and zygomatic breadth, 61 mm.

A specimen from near the Enterprise Mine, Taylor Park, had lost a couple of inches of its tail, and from the end of the remaining portion a little tuft of white hairs had grown. This animal was small for an adult, and Robert Hill, who collected it, said that all the marmots of this locality appeared to be small.

According to my investigations the east-west range of *luteola* is from Pike's Peak to Columbine Pass on the Uncompahgre Plateau.

Marmota flaviventris obscura. Dusky Marmot

Marmota flaviventer obscura Howell, Proc. Biol. Soc. Wash., vol. 27, p. 14, 1914. Type locality.—Wheeler Peak, 5 miles south of Twining, New Mexico (altitude 11,500 feet).

The dusky marmot is the subspecies inhabiting the Sangre de Cristo Range. The only Colorado records appear to be one specimen in the National Museum, probably from Sierra Blanca, or in that region, and 3 in my own collection, from the North Crestone trail. One was taken on the Comanche Lake branch of the trail, July 25, and 2 on the Venable Lake branch, July 26. The former was a male, the others females, but no distinction can be made between them on the basis of color. The localities are some 10 miles east of the town of Crestone, Saguache County, at nearly or quite 12,000 feet altitude. I have been unable to secure specimens from other localities in this range, and do not know just how far north along the Sangre de Cristo Range this marmot occurs. It was reported as very rare in the mountains at the head of Raspberry Creek, north of Villa Grove. Northwest of this place, the Sangre de Cristos merge into the comparatively low, timbered Poncha Hills, joining the Continental Divide or Saguache Range south of Marshall Pass. Hence the ranges of *luteola* and *obscura* are separated by a considerable distance.

All 3 of the above animals had completed the moult on the anterior half of the dorsal surface. The new pelage has white-tipped hairs. Below these is a zone, blackish brown with a reddish tinge, with Saccardo's umber beneath, and the base of the hairs is a blackish brown. The old or unmoulted pelage is slightly darker than seal brown. None of the 3 has a facial band. The chin and sides of the mouth are whitish, but not extensively so. The under parts of all 3 are very dark, the hairs here being tipped with white or buffy white, the basal color being near chaetura black. The new part of the tail is dark bay, the unmoulted part like the similar portion of the back. The feet are black.

The New Mexico records given by Howell and by Bailey are: Wheeler Peak, Truchas Peak, Agua Fria Peak, and the Taos Mountains, all of which are a part of the Sangre de Cristo Range.

Marmota flaviventris notioros. Wet Mountain Marmot

Marmota flaviventris notioros Warren, Jour. Mamm., vol. 15, pp. 62-63, 1934. Type locality.—Near Marion Reservoir or Lake, Wet Mountains, Custer County, Colorado, at about 10,000 feet.

Distribution. Wet Mountains and Greenhorn Range, in Custer, Pueblo and Huerfano counties, Colorado.

This is a large, dark colored marmot, with a comparatively slender skull. The general aspect of the animal is dark, with the dorsal hairs extensively white-tipped. The original description was given at length and it seems unnecessary to repeat it here.

Apparently this marmot occupies a region in Colorado isolated from the two nearest subspecies. On the north the nearest marmots are found some 60 miles distant on Pike's Peak and vicinity. The form there is the park marmot, *M. f. luteola*. To the west the dusky marmot, *M. f. obscura*, is found 35 miles away, on the high peaks of the Sangre de Cristo Range separated from the Wet Mountains by the Wet Mountain Valley, 20 or more miles in width.

GENERAL REMARKS

Young.—I have in my collection 12 small juvenal marmots, taken at localities that are well scattered over the area in which I have collected. There is considerable varia-

bility in the color of these specimens, varying from Brussels brown to chestnut-brown dorsally, and from antique to mummy brown and auburn ventrally. Three from Mud Springs, Garfield County, incline toward reddish brown.

Weight.—Four specimens of *luteola* weighed at Hot Sulphur Springs and Sheephorn Pass in April and May, varied from 4 pounds 2 ounces, to 4 pounds 12 ounces. The animals then were thin, having just emerged from hibernation. During the summers of 1933, 1934, and 1935, I weighed most of the marmots taken. The smallest weighed 5 pounds 8 ounces, the heaviest (a very fat animal) 11 pounds. The 3 *obscura* weighed 9 pounds; 9 pounds 4 ounces; and 9 pounds 6 ounces, respectively.

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MAMMALS OF THE ATLIN REGION, NORTHWESTERN BRITISH COLUMBIA

BY HARRY S. SWARTH[1]

The following list of mammals is founded mainly upon my own field work in the region. Entries are concerned primarily with manner of occurrence. The town of Atlin served as a base, and trapping for small mammals was carried on in the immediate vicinity and at points 10 to 20 miles east of the town. Observations based upon sight of diurnal mammals and information from miscellaneous sources cover the surrounding region from the White Pass and Carcross on the west to Lake Teslin at the east. Atlin, the town, lies on the east shore of Lake Atlin, altitude 2200 feet. In an air line it is only about 60 miles east of Skagway, Alaska, but the Coast Range mass lies between and faunal conditions are widely different on the two sides. West of the mountains is the Sitkan district of southeastern Alaska, a region of excessive humidity; east of the mountains is the semi-arid interior of British Columbia. The lowlands of the Atlin region are of the Hudsonian zone, giving way at about 3500 feet altitude to extensive Alpine-Arctic zone mountain summits. Atlin, as represented by animal species, is about at the dividing line between the Yukon fauna to the northward, and the central British Columbia fauna to the southward. I have given elsewhere (Swarth,

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1926) a detailed description of my principal collecting stations in the Atlin region, so need not repeat myself here. My field work, mainly concerned with birds, has covered the following periods: May 21 to September 24, 1924; June 16 to September 19, 1929; July 1 to October 23, 1931; March 27 to September 11, 1934. Specimens collected were as follows: 76 mammals in 1924, 30 in 1929, 217 in 1931, and 190 in 1934. With a few miscellaneous items acquired from various sources the total is about 530 specimens. The 1924 trip was made on behalf of the University of California Museum of Vertebrate Zoology; subsequent trips were for the California Academy of Sciences. In 1924 and 1929 I did my trapping unaided. In 1931 and 1934 my son, Morton T. Swarth, took over the trap lines and, with a little help in the choice of localities, assumed practically all of the labor involved. This made it possible to keep out many more traps, for longer periods, and in more places by far than I could have managed alone. Trapping was only for small mammals. No steel traps were used and no effort was made for "big game." A few furs and a few large skulls were purchased, and some were received as gifts.

The wide difference in numbers of specimens collected in 1924 and 1929 on the one hand, and in 1931 and 1934 on the other, is by no means entirely due to the greater efforts made in the last two years. It is mostly to be explained by fluctuations in the mammal populations. In 1924 small nocturnal mammals were extremely scarce (Swarth, 1926, p. 146) and in 1929 they were still more so; in 1931 they were noticeably abundant, in 1932 and 1933 I was told that "mice" swarmed as never before; and in 1934 again they had diminished appreciably. Rabbits and other diurnal mammals fluctuated in numbers, too, as noted beyond, but not in accordance with the "mice." It seemed to me that there must be different factors influencing the rise and fall of populations of certain mammal species, and still other factors affecting the grouse and ptarmigan, which also have their fluctuations.

Little field work besides my own has been done with mammals in this region. In the summer of 1899, W. H. Osgood traversed the White Pass on his way to the Yukon, collected at various places along the margin of the section of country that I am here treating, and named several forms that are included in this list (Osgood, 1900). F. Kermode and E. M. Anderson in 1913 (Kermode and Anderson, 1914), and E. M. Anderson the following year (Anderson, 1915), collected mammals about Atlin for the Provincial Museum, Victoria.

In the following list subspecific determination is based upon study of specimens at hand; the trinomial used represents in each instance a carefully considered conclusion. Besides the few cases where no specimens are available, there are others where the binomial is adhered to although the species in question has been subspecifically divided, and specimens were collected. There are a number of North American mammals, especially of the larger

species, with a plethora of subspecific names and no clear understanding by anyone of what those names represent, and several such species are here included. A list such as this can not go far beyond a reflection of the best current opinion, but I wish to emphasize the fact that at the same time little has been taken for granted and the names used have not been hastily adopted. It has been of inestimable advantage to me to have available the collections of the Museum of Vertebrate Zoology, and of no less advantage to be able to consult members of the staff thereof. I have had in particular the help of Dr. E. Raymond Hall in the identification of species and subspecies of *Myotis*, *Mustela*, *Zapus*, and of *Phenacomys mackenzii*; of Dr. Seth B. Benson with *Clethrionomys*. To Mr. T. T. McCabe I am indebted for the privilege of consulting his collection of mammals from central British Columbia, on deposit in the Museum of Vertebrate Zoology. To Mr. F. Kermode, Director of the Provincial Museum, Victoria, I am obliged for the loan of mammal skins collected in the Atlin region by himself and E. M. Anderson.

Atlin is remote from any other point whose mammals have been thoroughly studied, and it is to be expected that species in addition to those here listed will be found there in the future. Some, such as *Microsorex eximius*, may be foretold now with fair certainty; others may be as great a surprise as the one specimen of *Phenacomys mackenzii* that my son brought me in triumph one morning. The higher altitudes in particular, which I was hardly able to touch, will, I am sure, repay careful attention. Future revisionary studies of wide-spread species with local representation in this region, also, may entail niceties of classification beyond anything here attempted. With these several modifying factors understood, I submit this list as a fair present day picture of the mammal fauna of extreme northwestern British Columbia.

LIST OF SPECIES

Sorex cinereus cinereus I. Geoffroy. Masked shrew. Five specimens trapped in 1924, none in 1929, 7 in 1931, and 4 in 1934. Taken at the lake level and above timberline at 5000 feet altitude.

Sorex obscurus obscurus Merriam. Dusky shrew. Two trapped in 1924, none in 1929, 22 in 1931, none in 1934. In the same localities as *S. cinereus*, and up to 4,000 feet altitude.

Sorex palustris navigator Baird. Water shrew. One seen at the head of Otter Creek (4000 feet altitude), July 30, 1924. One trapped at Blue Cañon, about 3500 feet altitude, August 3, 1929. One is recorded by E. M. Anderson (1915, p. 19), trapped at the Warm Springs, 15 miles south of Atlin, 2200 feet altitude, July, 1914.

Myotis lucifugus lucifugus (Le Conte). Brown bat. One building in Atlin harbored large numbers of these bats, but they rarely were seen in flight. Nine specimens were preserved in 1931, 7 in 1934. On August 25, 1934, there was brought to me a live one that had been found clinging to the cushioned seat of an aeroplane at the end of a flight.

Myotis volans longicrus (True). Long-legged bat. There are 2 specimens in the Provincial Museum, Victoria, collected at Moose River, south end of Lake Atlin (Kermode and Anderson, 1914, p. 21). Date of collection is indicated on the labels as September 7, 1913; in the above cited report as September 11.

Ursus sp. Grizzly bear. This is still a fairly common animal in the Atlin region, and skins are brought to town by the Indians every year. One skull at hand answers the characterization of *Ursus crassodon* Merriam; two others (one with skin) that of *U. tahltanicus* Merriam. Grizzlies are seen mostly in the rough mountains west and south of Lake Atlin, but I saw one, on July 3, 1934, in poplar woods within 2 miles of the town of Atlin.

Euarctos americanus. Black bear. Of general distribution and not uncommon; seen at the lake level and as high as 5000 feet altitude. Both the black and the brown phases occur. The 2 black bear skulls that I have from this region are not of the *altifrontalis* type, which, according to Hall (1934, p. 365) occurs as far north as central British Columbia. The Atlin mode of skull extends at least as far south as the Stikine River (Swarth, 1922, p. 160). Subspecific determination of this form can hardly be settled at present.

Martes americana (Turton). Marten. A few skins are brought in by the Indians yearly, from points more or less remote from Atlin. I have never been able to obtain a skull, and with no personal records, do not know what subspecies occurs in the region.

Mustela cicognanii richardsonii Bonaparte. Richardson weasel. Occurring in numbers that fluctuate with the abundance or scarcity of mice. Said to have been extremely numerous in the great mouse winter of 1932–33.

Mustela rixosa (Bangs). Least weasel. On August 13, 1931, on a ridge above Wright Creek (about 5000 feet altitude), I found the posterior half of a freshly killed weasel of this species. In the summer of 1934 I was given a trapper's skin (without skull) of one that had been trapped at Blue Cañon (about 3500 feet altitude).

Mustela vison energumenos (Bangs). British Columbia mink. There are several mink farms in Atlin and nearby, the stock of which I was told is all derived from locally trapped animals. The one skull that I have, of a wild-killed mink, displays the characters of the subspecies *energumenos*. The farmed animals are of the dark color characteristic of that race.

Gulo luscus (Linnaeus). Wolverene. Apparently rather rare, although probably of general distribution. I heard of several that were killed nearby but have no personal records other than that of a skull obtained at Carcross (Swarth, 1926, p. 147).

Vulpes sp. Red fox. A single skull that I found on a ridge at about 4500 feet altitude (Swarth, 1926, p. 147) constitutes my only local experience with this species. Red foxes are trapped throughout this general region, and the fox population is consequently kept at a low level. I have no information as to local distribution nor any basis for an opinion of the specific or subspecific status of the local race. The black, so-called silver fox, occurs as well as the red-pelaged animal. Fox farms have been successfully operated at Carcross for some years.

Canis latrans incolatus Hall. British Columbia coyote. In the summer of 1924 coyotes were seen on mountain summits about 20 miles east of Atlin; none near the town. In 1929, 1931, and 1934, coyotes were seen or heard on many occasions in the immediate vicinity of the town as well as at more distant points. All told there were collected 5 skins with skulls, and 3 skulls without skins pertaining to animals trapped for fur during the winter months.

Canis lycaon Schreber. Timber wolf. On August 29, 1931, I purchased from an Indian the fresh skin (without skull) of a wolf that he had killed on August 27 on the slope of Monarch Mountain within 6 miles of Atlin. It was a female, black in color. This was the first to be seen so near Atlin for many years, but since then they have been on the increase. Under date of March 23, 1935, a friend residing at the Engineer Mine, Tagish Lake, writes that during the long winter they "had a little excitement watching the wolves. This is the first time they have been seen in this district. Several times we have counted ten and twelve in one band out on the ice about the mouth of Wyann

River. Have also seen them near Sheep Creek. I would be just as happy if they would go back to the Teslin district, where they belong."

Lynx canadensis Kerr. Canada lynx. A few are trapped each year. I have no personal records.

Marmota monax ochracea Swarth. Yukon marmot. Two specimens in the Provincial Museum, Victoria, were taken at Pike River, at the southern end of Lake Atlin, in July, 1914 (Anderson, 1915, p. 19). I have been told by other people of the occasional occurrence of this species in the lowlands, but have no personal records.

Marmota caligata caligata (Eschscholtz). Hoary marmot; Whistler. Occurs in scattered colonies at high altitudes, in fair abundance on some peaks and ridges, but absent from other places that are apparently just as suitable. I have seen none below about 4500 feet elevation. Specimens collected are of this subspecies.

Citellus plesius plesius (Osgood). Bennett ground squirrel; Gopher. A very common animal, especially at high altitudes. It is abundant around the railroad station at Bennett—the type locality—and also at Carcross. About Atlin the species is most numerous in open country above the 3500 foot level. I could not see that the swarming ground squirrel population of the preferred Alpine habitat was appreciably affected by factors that from year to year produced such amazing fluctuations in so many of the other rodent species. In the lowlands near Atlin, however, I found several small colonies, in limited tracts where in 1924 I could depend upon always finding a few ground squirrels, where in 1929 and 1931 there were none to be seen, and where in 1934 one or two of the squirrels had returned. In 1934 the first ground squirrels emerged from hibernation during the third week in April. Fifteen specimens were collected.

Eutamias minimus caniceps Osgood. Gray-headed chipmunk. Common in the lowlands. Chipmunks keep well below timber-line, and are especially characteristic of the poplar woods. In 1934 they emerged from hibernation early in March, with daily temperatures averaging a little above zero. I could see no fluctuation in numbers in chipmunks during different years. In 1924 I collected 9 specimens, 4 in 1929, 6 in 1931, and 18 in 1934.

Sciurus hudsonicus hudsonicus (Erxleben). Northern red squirrel. Common, mostly in the lowlands, and active to some extent throughout the winter. In 1929 red squirrels were less numerous than usual; otherwise there seemed slight fluctuation in numbers from year to year. In 1924 I collected 6 specimens, 4 in 1929, 1 in 1931, and 7 in 1934.

Glaucomys sabrinus alpinus (Richardson). Flying squirrel. An adult female trapped at the Warm Springs, 15 miles south of Atlin, March 6, 1934, appears to be, so far as can be determined from a single specimen, of the subspecies *alpinus* of central British Columbia. This capture is of especial interest as being at the center of a vast area from which the genus is otherwise unknown. The nearest point of record of *alpinus* must be nearly 500 miles to the southward, of *yukonensis* some 200 miles to the northward, and of the coastal *zaphaeus* about 200 miles to the southwest. Eastward is *terra incognita*. I believe that flying squirrels may be of fair abundance locally in the Atlin region, although I was able to get almost no information about them from trappers and woodchoppers. In 1924 I saw a bunch of perhaps 10 or 12 trapper's skins from the Warm Springs, the locality where my single specimen was taken.

Castor canadensis Kuhl. Beaver. As everywhere, beavers hereabout are trapped to the verge of extinction. They in all likelihood were originally abundant and generally distributed throughout the lowland lakes.

Peromyscus maniculatus borealis Mearns. Northern white-footed mouse. None trapped above timber-line. Specimens secured as follows: 13 in 1924, 6 in 1929, 37 in 1931, 18 in 1934. This species is always prone to invade human habitations, and when mice in general are abundant the white-footed mouse becomes a first-class nuisance.

My 1934 series consists of specimens selected from the much greater number that were trapped in our dwelling place. I cannot detect in my Atlin series evidence of the presence there of the subspecies *P. m. algidus* Osgood.

Neotoma cinerea saxamans Osgood. Northern bushy-tailed wood rat. My specimens were all taken below 3500 feet altitude. Negative evidence from cabins at high elevations seemed conclusive proof of the absence of wood rats above timber-line. They are regarded as a pest but I did not find the species abundant anywhere. Ten specimens were collected, 3 in 1924, 2 in 1929, 1 in 1931, 4 in 1934.

Lemmus helvolus (Richardson). Lemming. Although I have never been able to trap this species, I believe that locally, and in some years, it occurs in abundance. In 1924 I was told that the year before lemmings fairly swarmed in the highlands above Otter Creek, where then and in subsequent years I trapped without avail. I have one specimen, saved for me by R. M. Stewart, that was picked up on the frozen surface of Atlin Lake, May 6, 1931. I have another, skull only, from a carcass that I found August 13, 1931, at about 5000 feet altitude, on a ridge at the head of Wright Creek.

Synaptomys borealis dalli Merriam. Dall lemming-mouse. "Male taken at Wilson Creek on June 10 [1914]" (E. M. Anderson, 1915, p. 19). "One specimen . . . was trapped on upper Otter Creek (3800 feet altitude), on July 30 [1924]" (Swarth, 1926, p. 150). I have no other records.

Clethrionomys dawsoni dawsoni (Merriam). Dawson red-backed mouse. Found from the lake level near Atlin up to about 5000 feet altitude on a mountain-side above Blue Cañon. No specimens trapped in 1924, none in 1929, 70 in 1931 and 13 in 1934. A pregnant female taken August 3, 1931, contained 5 embryos.

Phenacomys mackenzii Preble. Mackenzie phenacomys. One specimen, adult female, trapped at the edge of the town of Atlin, August 6, 1931. This, I believe, is the first recorded occurrence of the species in British Columbia, the first perhaps, west of the Mackenzie Valley.

Microtus pennsylvanicus drummondii (Audubon and Bachman). Drummond meadow mouse. Trapped from the lake level near Atlin up to about 5000 feet altitude. Seen also on Third Island, near Atlin. We trapped 14 specimens in 1924, none in 1929, 38 in 1931, 52 in 1934. A pregnant female collected July 17, 1931, contained 5 embryos.

Microtus mordax mordax (Merriam). Rocky Mountain meadow mouse. Trapped from the lake level near Atlin up to about 5000 feet altitude. Found in exactly the same surroundings as *drummondii*. Trapped 9 specimens in 1924, 1 in 1929, 12 in 1931, 29 in 1934. Two pregnant females taken in 1924 contained 3 and 4 embryos, respectively. In 1931 and 1934 litters were all of 5 and 6 young. No gravid mice of any species were found later than the first week in August. Meadow mice of both species habitually invade human habitations, just as do the white-footed mice.

Ondatra zibethica spatulata (Osgood). Northwestern muskrat. Common throughout the lowlands. Muskrats persist in a slough at the edge of the town of Atlin, despite the immediate propinquity of the Indian village, the occupants of which are mostly trappers.

Zapus princeps saltator Allen. Stikine jumping mouse. Secured by me only in 1934, when 6 were trapped on dates ranging from July 31 to August 23, all in the immediate vicinity of Atlin. A specimen recorded as *Z. hudsonius* by Kermode and Anderson (1914, p. 21), collected at Moose River, September 12 or 14, 1913, proves to be *saltator*. Another was taken on Wilson Creek, July 15, 1914 (E. M. Anderson, 1915, p. 19). There is thus no verified occurrence of *Zapus hudsonius* in the Atlin region, although the species may be supposed to be there.

Erethizon epixanthum nigrescens Allen. Porcupine. Rare in the vicinity of Atlin. Although from time to time I heard of, and saw, dogs that had attacked porcupines nearby, the first that I encountered was an adult female that I collected about a mile

north of Atlin on September 3, 1931. Curiously, on the following day I came upon two together feeding on grass or bulbs far above timber-line, at about 5000 feet altitude on the mountain south of Blue Cañon. Hall (1934, p. 379) applies the name *nigrescens* to a series of porcupines from Bowron Lake, central British Columbia, affirming the existence of slight color differences that distinguish the British Columbia animals from *E. e. epixanthum* of California, and disallowing the presence of any cranial characters. I, on the contrary, am unable to recognize the color characters described; but I can see in my one Atlin skull the same features to which I drew attention in a discussion of crania from the Skeena River region, as distinguishing those from California specimens (Swarth, 1924, p. 380).

Ochotona collaris (Nelson). Cony. There are conies at the south end of Lake Tagish (Swarth, MS), and, according to E. M. Anderson (1915, p. 8), at the south end of Lake Atlin. I found no trace of conies on any mountains east of Lake Atlin nor any report of their occurrence in that general region. Howell (1924, p. 36) records the species from Lake Teslin, some 90 miles east of Atlin. The exact source of the specimens he cites is not known (R. M. Anderson, *in litt.*) but perhaps the lofty Dawson Peaks, near the south end of Lake Teslin, support an isolated colony.

Lepus americanus macfarlani Merriam. Mackenzie varying hare; snowshoe rabbit. Abundant in 1924 (5 specimens collected). In 1929 rabbits were all but totally absent; I saw 4 in the 3 months of my stay. In 1931 they were rarely seen throughout the summer months, but late in September they were obviously increasing. By the middle of October they were really abundant, and, I was told, remained so through 1932 and 1933. In 1934 they were fairly numerous in the spring and early summer, and when the young matured became more numerous than I had seen them before. Certain hay fields near town were encircled by denuded margins perhaps 10 feet wide, the length of two hasty leaps to the shelter of neighboring willow thickets, and in an evening's stroll to these fields one could sometimes see 20 or 30 rabbits. One shot April 4 is in white winter pelage but beginning to shed the white hairs. By the middle of May rabbits are more brown than white; by the end of the month entirely brown. Ears and feet are the last to turn brown and the first parts to turn white in the fall. By the end of September the change is well under way; by the middle of October adults are mostly white, with more or less of a brown "saddle" still lingering on the back. Young are slower than adults in assuming the white pelage, but the change must be generally accomplished in early November. Possession of white feet in summer pelage is an ascribed character of *macfarlani* and other northern hares (Nelson, 1909, pp. 50, 99), but not, I think, properly so. As above stated, feet and ears are the last parts to turn brown, the first to turn white, and, going northward, the white pelaged period is increasingly extended. Regardless of subspecies, therefore, the southernmost rabbits are more likely to have brown feet in summer and over a longer period. At Atlin few adults show entirely brown feet even in midsummer, but some certainly do; a more common condition is mottled brown and white. A female shot August 1, 1934, contained 5 embryos.

Alces americana Jardine. Moose. Of general distribution and in fair abundance, even close to town. The principal meat supply of all dwellers in the wilderness. The local belief is that moose have greatly increased in numbers during the past 20 or 30 years.

Rangifer caribou (Gmelin). Woodland caribou. It is many years since caribou have been seen near Atlin. Formerly they ranged over all the surrounding region east from the Coast Range. In 1934 I was told that caribou were then to be found around the north end of Lake Atlin, but I have no personal knowledge of their present status, either of range or numbers. In 1924 I found many shed caribou antlers, mostly at high altitudes, some within a few miles of Atlin. As these antlers had almost all disappeared

several years later, the inference would seem to be that they had been dropped not long prior to 1924.

Ovis "fannini" Hornaday. Mountain sheep. Before human settlement of the Atlin region mountain sheep occurred on most or all of the surrounding mountains, and they do so still on certain scattered summits. I have seen a good many skins from points between Lake Atlin and Lake Teslin, and while these showed some variability in markings, they were, generally speaking, all of the white-faced, black-bodied type to which the name *"fannini"* has been applied. They resembled the darker extremes of the animals figured by Sheldon (1911) as occupying this general region. Those that I saw resembled figures 7 and 8 in his plate (between pages 288, 289).

Oreamnos americanus (Plainville). Mountain goat. The Coast Range is the habitat of the mountain goat in this region, and the animals occur in abundance on the rugged eastern face of that range, as far as the western shore of Lake Atlin. On August 30, 1931, from the top of Llewellyn Glacier, near the south end of Lake Atlin, I counted 28 mountain goats in sight at one time on the adjacent mountain side, and there may have been as many more concealed for the moment by the underbrush. I saw none, nor sign of their presence, on any of the mountains east of Atlin.

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FOOD HABITS OF A WEASEL FAMILY

By Paul L. Errington

A series of holes comprising a weasel den was found June 22, 1934, in a patch of buckbrush or wolfberry (*Symphoricarpos occidentalis*) on a knoll in a pasture between Round and Trumbull lakes, Ruthven, Iowa. The holes were about 80 yards from Trumbull Lake and were thought to have been a system of burrows of the striped ground squirrel (*Citellus tridecemlineatus*) before having been utilized by the weasels (presumably *Mustela longicauda*).

The number of weasels frequenting this den and their exact status as a family group are not known. There was some popping of heads from different holes, and I thought that as many as 3 were in sight at once. Commonly two individuals, of sizes corresponding to an adult male and female, were to be seen at the main entrance to the den, both often protruding their heads from the hole at once.

An almost intact carcass of a juvenal red-winged blackbird (*Agelaius phoeniceus*) lay near the main entrance when the den was found in mid-afternoon. A weasel partly left the entrance in an unsuccessful attempt to snatch the bird out of hand as it was picked up; and when it was dangled over the hole, first one weasel and then the other tugged upon it. Parenthetically, I may remark that such boldness is not confined to weasels among the smaller mustelines. One of my earliest field notes (May 23, 1919, Brookings, South Dakota) describes the seizing of a crayfish (*Cambarus*) from my fingers by a small mink as I had started to examine it at the mouth of the mink's den.

Besides 3 or 4 fecal strings found scattered at random in the buckbrush, the bulk of the 32 samples of droppings gathered for analysis were deposited in the space of about one square foot, some feet beyond the main entrance of the den. No digging in search of underground latrines or prey caches was done, as it was desired that the den be left undisturbed; even so, the weasels apparently moved shortly thereafter, no positive evidence of subsequent use having been noted.

Exactly half of the 32 fecal samples (estimated at 31 per cent of the total volume) were composed of amorphous excretory material, or of dirt; 3 (7 per cent of total fecal volume collected) of feathers; and 1 (2 per cent) of egg shell particles. Insect remains were found in 13 samples—predominantly in one—and constituted about 4 per cent of the total fecal volume. Remains of small mammals comprised the balance of volume of this lot (about 56 per cent) and were found in 30 of the 32 samples.

Avian prey was represented by red-winged blackbirds and by unidentified fringillids in roughly equal proportions. The blackbird feathers recognized were those either of females or juveniles, probably the latter. The proximity of the weasel den to marshes on practically all sides doubtless made red-winged blackbirds as available as any bird species.

The fragments of egg shell gave no clue to their exact identity, except that they were from the eggs of some small bird, not improbably red-winged blackbird.

Only one of the 13 samples in which insects were represented contained a large quantity. Coleoptera strongly predominated, particularly ground beetles (*Harpalus*), then Hymenoptera (ants), with a few fragments of grasshopper (*Melanoplus*), and Muscidae (probably blowflies). The ants occurred chiefly in one fecal sample, and it is suspected that the flies were snapped up as they entered the den to deposit eggs on the putrefying carcasses usually to be found in such places at this season. (For descriptions of weasel dens see Seton, 1929, pp. 590–591, 618). The occurrence of ground beetles and grasshoppers, in proportions noticeably similar to those recorded the previous year in the diet of burrowing owls (Errington and Bennett, 1935) of the same general locality, seems only to reflect the availability of the insect prey which the weasels find on pastured land.

Striped ground squirrels bore the brunt of the weasel pressure, as 10 samples contained large amounts of the fur or bones of this animal and 6 others contained lesser quantities. Juvenal Leporidae were well represented in 9 samples; 2 of these were identified as *Sylvilagus* and most of the others probably were of cottontail also. Mouse fur or bones were found in 9 samples, of which 7 contained *Microtus* and 1, *Peromyscus*. The studies of Dearborn (1932, p. 37) and of Hamilton (1933, pp. 329–333) likewise emphasize the importance of mammalian prey in the food habits of weasels in other states.

There was a certain amount of unidentified material in the fecal samples, and, of course, it is entirely probable that items were eaten which passed through the digestive tract without leaving recognizable traces in the feces. The results of the analyses, nevertheless, may give a fair idea of mid-summer weasel food habits in the environment indicated.

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A NEW PLEISTOCENE DEER-MOUSE FROM SANTA ROSA ISLAND, CALIFORNIA

By Robert W. Wilson

Subsequent to 1928, collections of fossil vertebrate remains from Santa Rosa Island, California, have been made by the California Institute of Technology. These have included a considerable number of fragmentary remains of elephants (Stock, C., and E. L. Furlong, Science, vol. 68, pp. 140–141, 1928; Stock, C., Sci. Monthly, vol. 41, pp. 205–214, 1935). Material representing this mammal has been known from the island for more than 60 years, but, curiously, no other sort of fossil mammal was discovered in this locality until the fall of 1934, when there was collected in Pleistocene deposits a rodent specimen of the genus *Peromyscus*, quite distinct from the species inhabiting the area at the present time.

Peromyscus nesodytes, new species

Locality and Geological Horizon—Locality 106, Calif. Inst. Tech., Coll. Vert. Pal., Santa Rosa Island, Santa Barbara County, California; Pleistocene.

Type Specimen—A right ramus with M_1–M_3, no. 1780, Calif. Inst. Tech. Coll. Vert. Pal.

Specific Characters—Partially bipartite antero-median cusp in M_1. Antero-internal valley in M_1 V-shaped. No accessory tubercles on cheek-teeth. Size very large, slightly larger than *Peromyscus antiquus*. Length of tooth-row, M_1–M_3, 5.9 mm.

Remarks.—The outstanding character of *P. nesodytes* is its large size, which is greater than any living species of *Peromyscus* native to the United States; it appears to be exceeded in size only by members of the subgenus *Megadontomys* of southern Mexico and Central America.

There exists in the cheek-teeth of *Peromyscus* a relatively large amount of individual variation. Hence, the following discussion is subject to some uncertainty, inasmuch as *P. nesodytes* is known only from a single specimen.

The cheek-teeth of *P. nesodytes* are comparable in size—relative to each other—and in shape to those of living members of the genus. Absence of supplementary tubercles in the cheek-teeth and the large size of *P. nesodytes* suggest relationship with the subgenus *Haplomylomys*, and especially with *P. californicus*. The fossil species not only exceeds the latter in size, however, but the antero-median cusp of M_1 is separated from the antero-internal cusp by a pronounced V-shaped valley. In *P. californicus* the valley is extremely compressed and parallel-sided, and the anterior and posterior enamel borders with wear show a tendency to become united at the inner margin of the tooth. When the latter condition exists, the outer tip of the valley commonly assumes a lake-like appearance.

A number of specimens of *P. californicus* were studied and the last-mentioned character apparently is significant for both *P. c. californicus* and *P. c. insignis*. In a recent paper by Grinnell and Orr (Jour. Mamm., vol. 15, pp. 210–220, 1934), *P. californicus* is differentiated into 5 races instead of the 2 heretofore recognized. The specimens studied in the present connection apparently do not represent all 5 of these races but are from sufficiently varied localities to indicate that the character under discussion is not one of merely subspecific value. Reference to *P. c. californicus* in this paper is not to the race as restricted by Grinnell and Orr, but to the subspecies recognized by earlier authors.

An additional character which may help to distinguish the fossil species from at least some races of *P. californicus* is the partially divided antero-median cusp in M_1. In *P. nesodytes* the division is quite clearly marked and is distinct enough to give some indication of its presence even in worn teeth. In *P. c. californicus*, as represented by the series of specimens of this subspecies examined during the course of the present study, it is generally but not invariably absent. In *P. c. insignis* the divided antero-median cusp sometimes is present.

Peromyscus eremicus is another member of the subgenus *Haplomylomys* with which comparison might be made. In several of its characters it resembles the fossil species. The inner borders of the antero-internal valley are usually separate as in the Pleistocene type, although the re-entrant V is commonly narrower and more parallel-sided. *P. e. eremicus* has a bicuspate antero-median cusp in M_1 as in *P. nesodytes*. The species is much smaller than the new type, however. On the other hand, there are cases of insular rodents that are larger than related mainland forms, and it is not outside the bounds of possibility that the Santa Rosa Island form is an extremely large member of the *eremicus* group. With only the present material available this hypothesis can be neither

FIG. 1. Type specimen of *Peromyscus nesodytes*, right ramus with lower dentition, no. 1780 Calif. Inst. Tech. Vert. Pal. Coll.; lateral view and occlusal pattern of teeth; approximately ×3.

proved nor disproved. Doctor E. Raymond Hall has suggested to the author that a species identical with or similar to *P. nesodytes* may now be living on Santa Rosa Island, but has not been recorded in the Recent fauna.

The principal character distinguishing *Haplomylomys* from other subgenera of *Peromyscus* is the absence of supplementary tubercles in the cheek-teeth. This feature is not absolute and certain species of the subgenus *Peromyscus* approach *Haplomylomys* in this respect. This is especially true of the lower cheek-teeth. *Peromyscus* (*Peromyscus*) *maniculatus* is a species in which the intermediate tubercles of the lower dentition are rather poorly developed, at least in some races, and individual specimens may have these cuspules practically nonexistent. The insular race *P. maniculatus streatori* inhabits Santa Rosa Island at the present time. This form is much smaller than *P. nesodytes* and moreover does not possess the divided antero-median cusp on M_1. *P. m. streatori* resembles the fossil form, however, in shape of the antero-internal valley in M_1.

Representatives of the subgenus *Megadontomys* surpass *P. nesodytes* in size. The subgenus is characterized, however, by very prominent accessory cusps, even in the lower molars, and thus is readily distinguished from the island form.

Previously known extinct types of *Peromyscus* appear to be farther removed from *P. nesodytes* than are some of the living forms. *P. antiquus* (Kellogg, L., Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, pp. 432–433, 1910) from the Thousand Creek beds of northwestern Nevada agrees fairly closely with *P. nesodytes* in size but has a large M_3, whereas in our type and in Recent species M_3 is more reduced. In addition, *P. antiquus*

has a strong antero-external ridge in M_3. In *P. nesodytes* the stage of wear makes it difficult to determine the development of this character, but presumably the ridge is rather weak.

Contribution no. 183, Balch Graduate School of the Geological Sciences, California Institute of Technology, Pasadena, California.

GENERAL NOTES

AN OPOSSUM DIES OF COLD AND HUNGER

An opossum, found in a snow drift near Ann Arbor, Michigan, on March 8, 1936, by A. S. Hazzard and examined by myself, is believed to have died of cold and hunger. Hazzard discovered the dead animal in a hedge-row at his home, 4 miles east of Ann Arbor, when it was revealed by the melting of the drifted snow. It may have died any time during the 6 or 8 weeks of cold weather preceding the thaw. During that time zero or near-zero weather prevailed, and the ground had an unusually thick covering of ice and snow.

An examination of the carcass revealed no injuries nor evidence of disease, but the animal was very lean. The digestive tract was empty except for a small amount of debris in the stomach. This consisted of fragments of dead sticks, weeds and grass and a quantity of gritty material, apparently dirt, that the opossum had eaten, evidently in a desperate attempt to ward off starvation. Undoubtedly many small mammals suffered during the cold weather, but this is the only record that I have of one succumbing to it.—W. Frank Blair, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

WINTER DAYTIME DENS OF OPOSSUMS

During the months of November and December, 1925, in Webster County, Mississippi, the writer took 36 opossums from self-chosen day-time dens. Every individual was removed from its den during daylight hours, and most of the specimens, except those taken several feet above the ground, were located by a dog. The following table shows the occurrence of opossums by den types:

OPOSSUMS TAKEN IN:	NUMBER			PER CENT OF TOTAL
	Male	Female	Total	
Trees (standing, green or dead)	4	2	6	16.7
Logs (horizontal, on or above ground)	5	6	11	30.5
Stumps (hardwood, old and decayed)	1	2	3	8.3
Debris (slashings and brush on ground)	2	1	3	8.3
Vine-brush tangles (at swamp borders)	2	0	2	5.6
Leaf dens (squirrel? dens in branch crotches)	2	0	2	5.6
Underground dens (cavities in soil)	3	4	7	19.4
Attic of abandoned house (third floor)	1	1	2	5.6
Totals	20	16	36	100.0

In 3 instances 2 opossums were taken in single dens, but no den yielded more than 2 individuals. The sexes never were mixed, as 2 dens produced 2 females each and the

third den 2 males. All 3 dens were in horizontal logs: red elm (*Ulmus fulva*), 2 females, 7 feet above ground; black gum (*Nyssa sylvatica*), 2 females, one foot above ground; and post oak (*Quercus stellata*), 2 males, one foot above ground. In a fourth instance, 2 opossums, a male and a female, were taken from the same attic, but were separated by the width of a small room. Each animal had denned in the casement of a window.

All individuals, except those taken in underground dens and 2 from debris at approximately the ground level, were found in dens a foot or more above the surface soil. The highest den was 40 feet above the ground in a cavity in the bole of a three-foot post oak. Two specimens were taken in leaf dens placed, undoubtedly by fox squirrels, in branch crotches. These dens were at heights of 16 and 20 feet in black and white oak trees, respectively. The opossums taken from the attic were about 17 feet above the ground. The occurrence of dens by height levels was as follows:

HEIGHT LEVEL	NUMBER OF DENS*	PERCENT OF TOTAL
Underground dens	5	15.2
Ground level and 1 foot up	12	36.4
Above 1 and up to 5 feet	7	21.2
Above 5 and up to 10 feet	2	6.1
Above 10 feet	7	21.1
Totals	33	100.0

* In determining the number of dens, those containing 2 animals were counted as one; attic counted as 2 dens.

The deepest underground den ran to a depth of about 2.5 feet. It was located under a small bluff bordering a narrow run. The entrance of the burrow was just to one side of the roots of a ten-inch persimmon tree. None of the burrows ran more than 6 feet horizontally.

The habitat location of the dens was as follows:

Woodlot	6	Edge of swamp (between swamp and cut-over pine timber; dens in vines)	1
Pasture	10		
Hardwood timber (not cut over)	5	High school campus (wooded)	1
Pine timber (cut over 3–5 years before)	4	In attic of abandoned house	2
New ground (cleared of brush, logs left)	4	Total number of dens	33

All specimens were taken in the shortleaf pine highland region of Mississippi, from an area less than a township in size, most of which had been cut over within the preceding five-year period. At least half of the area is burned over annually. Less than 5 per cent of the land was under active cultivation, but most of the wooded lands were lightly pastured. The cut-over areas apparently recovered their attractiveness for opossums within 2 or 3 years after being logged, and in hardwood areas where varying numbers of large hollow trees were cut, the general opossum habitat probably was improved. In regard to the occurrence of opossum in northern Mississippi, fire appears to be the only distinctly destructive factor associated with man's occupation of the soil. The small area farmed is believed to improve habitat conditions.—LEE E. YEAGER, *School of Forestry and Conservation, University of Michigan, Ann Arbor, Michigan.*

NOTE ON THE HABITS OF BLARINA

On April 12, 1936, at Princeton, New Jersey, I had the opportunity of watching a short-tailed shrew (*Blarina*) at work. The day was dull, with occasional rain, no wind, and temperature about 45 degrees F. At 10 A.M. my attention was arrested by the movement of some dead leaves on the bank of a small stream about six feet distant. I watched for a few minutes before a *Blarina* popped out onto the surface of the ground.

The shrew was gathering dead leaves. It worked quickly, tugging an entire leaf underground and then reaching for another. It apparently was indiscriminate in its choice, groping about at the mouth of its tunnel, grasping with its teeth whatever it could reach and drawing it back into the burrow. It took dry sycamore, maple, green briar, and oak leaves, but no green material. When it had exhausted the leaves within an inch or so of its burrow, it tunnelled a few inches beneath the mold and commenced operations in a new spot, rarely exposing the tip of its nose to view. It paid no attention to several large earthworms that were within easy reach.

This gathering of leaves continued for 20 minutes, when I left the spot. An inspection of the site on the following day revealed little. I found several shallow runways blocked by loose soil but no evidence of the leaves that had been gathered from the surface.—D. G. Nichols, *116 Ninth Street, Garden City, New York.*

RELATIVE WING RATIOS OF BATS AND BIRDS

While gathering data on the ratio between weight and wing area of birds, the writer weighed, and traced the wing outlines, of such species of Pennsylvania bats as came into his hands. On checking over this material several rather interesting comparisons became evident.

In order fairly to compare the wing ratios of bats with those of birds, it, of course, is necessary to select such species of birds as have similar flight characteristics, flying for protracted periods, and feeding very largely on the wing. There are relatively few birds that justly may be compared on this basis with bats. These would comprise the swallows, swifts, humming birds, and possibly the petrels. Most other species of birds are less strictly aerial in habits and employ their wings simply to travel from one place to another.

In comparison even with the birds mentioned, bats have flight characteristics that are distinctly different. The flight of the smaller species of bats, as a rule, is slower and changes in direction more abruptly. The humming birds probably have as efficient control, but this is gained by phenomenal development of the pectoral muscles, accompanied by a reduction of wing area. The same condition is found, to a degree, in the swifts, and to a still lesser degree in the swallows.

There are few cases, unfortunately, in which a direct comparison of weight may be made, but sufficient data are presented to suggest a functional relationship between bats and birds.

Among birds there normally is a definite diminution of ratio from the smallest species to the largest, just as is the case with bats. The highest ratio found is 8.87 square cm. per gram, in the golden-crowned kinglet, weighing 5.75 grams; the lowest, 0.53 square cm. per gram, in the old squaw, weighing 1038 grams.

No birds appear to have anything approaching the ratio of the smallest bats, 16 (square cm. per gram) for *Myotis keenii septentrionalis*, and 19.30 for *Myotis subulatus leibii*. It is only in the larger, more swiftly flying species, such as the lasiurine bats, with long narrow wings more comparable to those of birds, that one finds ratios closely approaching those of the latter. Thus the figures for *Lasiurus borealis*, *L. cinereus*, and *Eptesicus fuscus* approach very closely those of the swallows and swifts of the same weight, while the two smallest bats, *Myotis s. leibii* and *Myotis k. septentrionalis*, have

twice the relative area of the golden-crowned kinglet and considerably more than 3 times that of the two species of humming birds measured.

The higher ratio of bats in general may be very useful when carrying young, as several species are known to do. I have taken in flight a female hoary bat, *Lasiurus cinereus*, weighing 27.10 grams, bearing two young totaling 10.5 grams. It is doubtful whether any of the smaller birds could duplicate this feat. On the other hand, the petrel has a higher ratio than any other birds or bats of corresponding weight.

The measurements here given were taken from freshly killed specimens, and are areas of both alar membranes, as measured with a polar planimeter. A comparative table is presented herewith.

	WEIGHT	WING AREA	RATIO
Mammals			
	grams	*sq. cm.*	
Myotis subulatus leibii	3.20	62	19.30
Myotis subulatus leibii	4.12	61	14.80
Pipistrellus s. subflavus	4.25	59	13.88
Myotis k. septentrionalis	4.50	72.6	16.00
Myotis l. lucifugus	5.00	62	12.40
Myotis sodalis	6.75	81	12.00
Myotis l. lucifugus	7.5	75	10.00
Lasionycteris noctivagans	9.70	85	8.76
Lasiurus borealis	13.5	96.5	7.14
Eptesicus f. fuscus (male)	14.30	98	6.85
Eptesicus f. fuscus (female)	18.30	118	6.45
Lasiurus cinereus	25.1	159	6.33
Birds			
Archilochus alexandri	2.55	12.75	5.00
Archilochus colubris	2.98	12.40	4.16
Regulus s. satrapa	5.75	51	8.87
Corthylio c. calendula	6.73	58.25	8.66
Certhia familiaris americana	8	66.5	8.31
Geothlypis t. trichas	9.5	58.53	6.26
Spizella p. passerina	13.5	91	6.74
Seiurus n. noveboracensis	14.5	86	5.93
Stelgidopteryx ruficollis serripennis	15.75	107	6.79
Hirundo erythrogaster	17	118.5	6.96
Chaetura pelagica	17.3	104	6.00
Iridoprocne bicolor	20.1	125	6.22
Oceanodroma l. leucorhoa	26.5	251	9.47
Progne s. subis	43	185.5	4.32

EARL L. POOLE, *Reading Public Museum, Reading, Pennsylvania.*

MYOTIS VOLANS INTERIOR IN SOUTH DAKOTA

While engaged in field work for the Cleveland Museum of Natural History, Mr. G. W. Phillips and the writer secured, on August 5, 1929, one specimen of *Myotis volans interior* Miller at Bull Springs, Custer County, South Dakota. The animal was an

adult male that had been hanging under the eaves of a building on the ranch of George Sturm. The altitude of the locality is 6500 feet. From the available literature, I believe that this is the first record of this form for South Dakota, the known range as given by Miller and Allen (U. S. Nat. Mus. Bull. 144, p. 136) thus being extended about 150 miles to the northeast.—PHILIP N. MOULTHROP, *Cleveland Museum of Natural History, Cleveland, Ohio.*

EUMOPS IN FLORIDA

During a recent visit which Dr. David Fairchild and I paid to Mr. C. A. Mosier, a naturalist of wide interests, he told us of a peculiar bat that had been caught by one of the pupils of Mrs. Palmer, who teaches biology in the Edison High School, North Miami, Florida. We visited her laboratory, where she had the stuffed bat spread on a board.

By a curious coincidence Eliott Bacon, my wife and I, 20 years ago, chased a bat about the dining-room table in a small country hotel at Madruga, Cuba. We bottled the bat and sent it to Cambridge, and this was the first and only time that I ever saw *Eumops glaucinus.*

The peculiarly fierce appearance of this bat made such an impression that I recognized it when I saw it again in the hands of Mrs. Palmer. Dr. G. M. Allen has confirmed the identification, and the bat has been returned to Mrs. Palmer.

The species is rare in Cuba. There are fruit steamers that ply frequently between Miami and Sama in eastern Cuba, and it is possible this bat may have reached Florida on one of the boats. I can think of no other explanation of its presence.—THOMAS BARBOUR, *Coconut Grove, Florida.*

MICHIGAN RECORDS OF THE LEAST WEASEL

More systematic trapping has been done in Michigan, perhaps, than in any of the other Great Lakes states, yet no mammalogist in this state as yet has secured in his own traps and recorded a specimen of the least weasel. The single specimen obtained and heretofore reported (Dearborn, Jour. Mamm., vol 13, p. 277, 1932) was caught by a cat at Rochester, Oakland County. Two other specimens, both from Oakland County, now may be recorded.

Pits as small mammal traps have been used with notable success by the late F. J. W. Schmidt and others. Infrequently utilized for this purpose are the excellent catch-alls of areaways to basement windows, and one of these in the building of the Cranbrook Institute of Science, Bloomfield Hills, Michigan, has yielded one of the specimens here reported. A student, Henry Duffield, in a periodic examination of the areaways on March 22, 1936, picked out the carcass of an adult male *Mustela rixosa allegheniensis.* It is presumed that the weasel was attracted to this place, which was 40 inches deep and faced with concrete, by mice that first may have fallen into it, or by the laboratory mice and rats kept in the room inside the basement window. Although this is screened it often is partially opened for ventilation. Snow had fallen within two weeks of the time that the specimen was secured. Skinning the animal was impracticable because of advanced decomposition, but its complete skeleton is in the collections of the Institute.

The pelage of this specimen was completely white except for a small patch of brown between the eyes, another over the occiput, and a dozen black hairs at the tip of the tail.

The third Michigan specimen came to light as a direct result of a publicity item inserted in local papers. A farmer living 2 miles north of Rochester wrote of a specimen he had secured in the autumn of 1935 and had mounted. This, he said, was the second individual of the least weasel that he had secured. The mounted animal, in

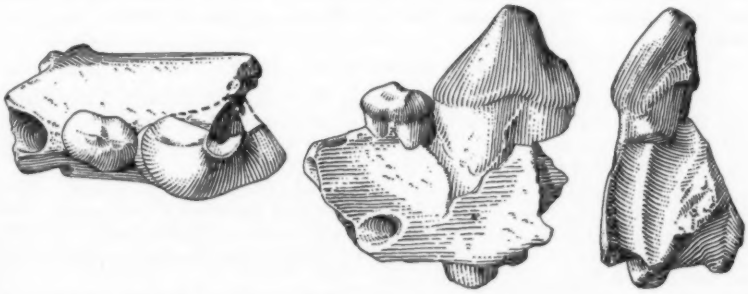
the brown coat with some beginnings of the winter white, also has been added to the collections of the Institute.—ROBERT T. HATT, *Cranbrook Institute of Science, Bloomfield Hills, Michigan.*

AN UNUSUAL SPECIMEN OF RED WOLF

On February 11, 1936, the mammal laboratories of the U. S. Biological Survey received a red wolf skin and skull collected near Mineral Wells, Palo Pinto County, Texas, by E. G. Pope, a member of the Bureau staff. This animal was unusual in that some of the toe pads were grown together at the base. Concerning this wolf and others Mr. Pope reported as follows: "Out of a pack of six wolves that I caught in Cantey's goat pasture, two were extremely large, as big as a lobo. All the individuals of this pack had the middle toe pads on all four feet grown together at the base."—VIOLA S. SCHANTZ, *U. S. Biological Survey, Washington, D. C.*

NOTES ON THE TYPE OF BOROPHAGUS DIVERSIDENS COPE

Through the courtesy of the Department of Geology of the University of Texas, Mr. R. A. Stirton, of the University of California, recently has searched through their collections for Cope's original vertebrate types from the Blanco Pliocene of the Texas Panhandle. The search was partially successful and among other specimens found and loaned to the University of California were the type and paratypes of *Borophagus diversidens*. This form was described by Cope in 1892 as a hyaenid and consisted of the anterior part of a "left lower jaw with two premolar teeth in place and the alveoli of the anterior premolar and the canine." Paratypes were "a robust conic crown with a small conic cusp at its base and an anterior blade of a sectorial." In 1893 appeared Cope's Report on the Vertebrate Paleontology of the Llano Estacado, and the author



Genotype of *Borophagus diversidens* Cope from the Blanco Upper Pliocene of the Texas Panhandle. Fragment of a left lower jaw bearing Pm3–4. Original in the collections of the Department of Geology, University of Texas. Natural size.

noted that the paratypes "are at this time lost." Subsequently, the type appears to have been lost, and no worker has been able to study it until its present reappearance. When Merriam described the new genus *Hyaenognathus* in 1903, he was well aware of its possible identity with *Borophagus*, but felt justified in using a new name because of the anomalous characters of the paratypes and the fact that the originals were thought to be lost. For the same reason, Stirton and VanderHoof, in 1933, hesitated to place *Hyaenognathus* in the synonomy of *Borophagus*. Now that the type and paratypes of *Borophagus diversidens* are available for study, the status of this form may be stated as follows:

1. *Borophagus diversidens* is a canid and not a hyaenid.
2. Cope's paratypes of *B. diversidens* are (a) milk teeth of a large dog close to *Canis dirus*, and (b) a worn M^1 of the same.
3. *Hyaenognathus* is a synonym of *Borophagus*.
4. The species of *Borophagus* now known as valid are: *B. diversidens*, the type species; *B. pachyodon*, *B. solus* and *B. matthewi*.

The measurements of the type of *Borophagus diversidens* are as follows (the last column of measurements are Cope's figures):

PM^4	Sagittal	22 mm.	28 mm.
PM^3	Sagittal	11.5 mm.	10 mm.
PM^3	Transverse	8 mm.	8 mm.
Thickness of jaw below P^4		20 mm.	

V. L. VANDERHOOF, *Museum of Paleontology, University of California.*

GENITAL SWELLING IN A FEMALE GORILLA

One day during the latter part of August, 1929, I was trailing a group of gorillas (*Gorilla beringei*) in the mountains near Chibinda (or Tshibinda), which is west of the southern end of Lake Kivu, in the Belgian Congo. Unexpectedly I was afforded a clear, although brief, view of an apparently adult female gorilla at a distance of about 40 yards. She was walking almost directly away from me, up a slope on a well-worn trail, and was visible during the time that it took her to walk a distance of 6 or 8 feet.

The genital region of this individual was swollen, pale in color, and appeared to be tumid. I judged that the swelling was similar in size to that of a female chimpanzee during maximum enlargment, and thus proportionately smaller, considering the larger size of the gorilla.—H. C. RAVEN, *American Museum of Natural History, New York, N. Y.*

MAMMALS CAUGHT IN POST HOLES

Zapus hudsonius hudsonius has been rare in the vicinity of Windsor, Connecticut, until the spring of 1935. During two years of trapping by D. G. Nichols and myself only 4 of these mice were secured. One was taken alive in the spring of 1932, 2 were trapped in the fall of 1933, and one in the fall of 1934.

In May 1935, about 200 post holes were dug around a tract of swampy ground. They were from 3 to 4 feet deep, one foot in diameter, and set about 15 feet apart. The surrounding land is covered with marsh grass, wild raspberry bushes, poison ivy, and a few other bushes and small trees. There are several small streams, a pond at one end, and a marsh in the center of this area.

On May 5 I startled a jumping mouse from a tuft of grass on the edge of the pond. It ran a few yards, tumbled into a post hole partially filled with water, and drowned. From May 7 until June 5, I made a daily circuit of these holes, and from them I secured a few frogs and turtles, several snakes, and about 75 mammals, including 32 *Microtus*, 26 *Zapus*, 8 *Blarina*, 3 *Peromyscus*, 2 *Sylvilagus*, and 1 *Marmota*.

Zapus seldom is considered to be an abundant rodent, although at times it may be rather common locally. My experience had indicated that at Windsor it not only is restricted in locality, but also fluctuates in numbers, occasionally being abundant.—JOHN J. CHRISTIAN, *645 Taylor Ave., Scranton, Pennsylvania.*

THE TYPE LOCALITY OF SCIURUS APACHE ALLEN

Sciurus apache was described by J. A. Allen (Bull. Amer. Mus. Nat. Hist., vol. 5, p. 29, 1893) from 2 specimens collected by the Lumholtz Expedition of 1890–1891 across

the Sierra Madre of northern Sonora and northern Chihuahua. In this description the type locality was given as "Northern Chihuahua," although tentatively so, since both of the specimens were without labels when received. Miller, in his List of North American Recent Mammals, 1923 (p. 228, 1924), gave the type locality as "Mountains of northwestern Chihuahua (near Bavispe River?), Mexico."

I have had access recently to Lumholtz' two-volume, popular work "Unknown Mexico" (Charles Scribner's Sons, New York, 1902). The first chapters of volume 1 give considerable data concerning the itinerary of the party, and clarify much of the ambiguity regarding the localities of Allen's list of the birds and mammals collected. Pages 24 to 50 deal with the progress of the party across certain mountain ranges between Nacori in east-central Sonora and the main ridge of the Sierra Madre in west central Chihuahua. The easternmost of these ranges is the Sierra de Nacori, a lofty chain separated from the Sierra Madre proper by the great northern loop of the Bavispe River. It was in this range (p. 36) that "Here too, Mr. Robinette shot a new species of squirrel, Sciurus Apache." The site of the camp was at an altitude of 6300 feet in an (apparently) mixed growth of pines and hardwoods. It also is clear from the account that the site was on the western slope, some 29 (trail?) miles east of Nacori. The date was between December 2, 1890, at which time the party left Nacori, and December 24, when the party had decended the eastern slope of the range and was on the Bavispe River. The main Sierra, east of the Bavispe, was ascended a few days later, and the Chihuahua boundary was crossed about January 1, 1891.

From the above data it seems that the type locality of *Sciurus apache* may be fixed as the western slope of the Sierra de Nacori in eastern Sonora, at an altitude of 6300 feet.—A. J. VAN ROSSEM, *San Diego Society of Natural History, San Diego, California.*

FOX SQUIRREL SERIOUSLY DAMAGES ELM TREE

During the 3 weeks from March 25 to April 15, 1936, I observed the activities of an adult fox squirrel in barking the branches of a three-inch white elm on the University of Michigan campus. The tree is about 12 feet tall with a crown spread of about 9 feet, a result of having been topped several years ago.

This squirrel, evidently a female, carried the bark, as soon as it was torn from the tree, to a cavity in a silver maple about 25 feet above the ground. This tree stands 20 or more feet from the elm. In removing the bark, the squirrel worked chiefly on the top and sides of the branches; only in a few places was the bark on the under side removed. The animal separated the bark by inserting the front incisors under it and pulling up or to one side. The bark torn off at each attempt was held in the mouth until several "bites" had been made, after which the squirrel carried the load to the cavity. Nearly all of the branches were barked to some degree, and it is estimated that about 60 per cent of the total bark of the branches was removed.

I know of one other instance, also in southern Michigan, where a fox squirrel barked the branches of a tree in similar manner. This tree, a catalpa, also had been topped, and its branches were spreading and largely horizontal as in the above case.

During the last 3 years I have observed some of the activities of the heavy squirrel population in Ann Arbor, Michigan, and have seen no other instances of damage to trees as serious as the above. This may serve to indicate that (1) severe barking of trees is not common and that the squirrels should not be condemned for exceptional cases, and (2) only certain trees are attacked, perhaps those with wide, flat tops, the bark of which may suit the taste or fancy of an individual squirrel.

In the case of the elm tree barking, the squirrel was observed to work on both clear and cloudy days, and on one occasion, at least, during a light flurry of snow. It is almost certain that one squirrel did all of this barking, and that practically every fragment of the bark was carried to the cavity in the silver maple tree. A litter of 5

fox squirrels was born in the cavity during the 1934 season.—Lee E. Yeager, *School of Forestry and Conservation, University of Michigan, Ann Arbor, Michigan.*

A PREDATOR ELIMINATES A SICK ANIMAL

In Palo Alto, California, early on the morning of January 15, a gray squirrel (*Sciurus griseus nigripes*) dashed across a wet pavement, followed by a large house cat. The squirrel gained the opposite side of the street but instead of climbing an available tree beside the curb, it circled the tree and a parked automobile and came out again on the pavement, where the cat captured it. The cat carried the squirrel to the lawn by a house, where I had a chance to examine it closely. It was a mangy, bedraggled squirrel with half its tail gone and lacking most of the body hair. The incident seemed to be an example of a predator functioning in a beneficial manner, by placing a diseased animal in permanent quarantine. A healthy squirrel easily could have escaped the cat.—Adolph Murie, *National Park Service, Omaha, Nebraska.*

THE TAXONOMIC STATUS OF DIPODOMYS HEERMANNI BERKELEYENSIS GRINNELL

Twelve specimens of *Dipodomys heermanni* have been collected recently on Mount Diablo, Contra Costa County, California. Mt. Diablo is approximately 20 miles in an air line due east of Berkeley, the type locality of *D. h. berkeleyensis*. No barrier to kangaroo rat distribution is known to exist between the two places, and the areas in Berkeley and on Mt. Diablo from which the rats were obtained evidently are quite similar as regards ecological requirements for kangaroo rat existence.

In 1922, Grinnell (Univ. Calif. Publ. Zool., vol. 24, p. 52) tentatively outlined the range of *berkeleyensis* as "Presumably the Mount Diablo range and adjacent hills to the east of San Francisco Bay." At that time only 4 specimens were at hand, all from Berkeley. Only 2 of these were adults preserved as skins with skulls.

There are several good differences for separating subspecifically the Mt. Diablo specimens from each of the races of *D. heermanni* other than *berkeleyensis*. The only absolute distinction found between the latter and the Diablo specimens is in the character "width of rostrum near end" (minimum width 4.2 mm. in *berkeleyensis*; maximum width 4.0 mm. in Diablo material). In each remaining character studied the 2 adult topotype skulls of *berkeleyensis* fall within the range of variation established by the 12 specimens from Mt. Diablo. Only average differences would allow subspecific separation of Berkeley and Mt. Diablo specimens. No large series is available, however, to permit computation of any "average" of the race at Berkeley; and the average differences, as established by the material at hand, are not sufficient in my opinion to warrant designation of the Diablo specimens as a distinct race.

The concept of the race as here set forth, therefore, may differ from that which could be formulated by examination of a large series from Berkeley. This concept, however, as outlined in the following paragraphs, may aid in firmly establishing *berkeleyensis* as a distinct, recognizable race.

Close comparison was made with the races *heermanni*, *goldmani*, and *tularensis*. For comparisons of pelage coloration of these forms with that of *berkeleyensis*, see Grinnell (*op. cit.*). Cranial comparisons follow.

Dipodomys h. berkeleyensis differs from each of the above 3 races as follows: Size, smaller (smallest of the races of *heermanni*); inter-parietal and supra-occipital conspicuously broader; bullae smaller and less inflated; top of skull sloping markedly to most posterior protruberances of mastoid bullae. (Thus the end of the skull in profile is less truncate.) From *heermanni* it differs further in its smaller ear and shorter terminal hairs of tail. (From tip of tail proper, maximum of 5 specimens of *heermanni*, 29 mm., and averaging 15 per cent of tail length; maximum of 11 specimens of *berkeleyensis*, 24 mm., and averaging 12 per cent of tail length.)

Dipodomys h. berkeleyensis further is distinguishable from *goldmani* in its proportionately shorter tail and less procumbent incisors. All characters considered, *berkeleyensis* shows greatest similarity to *goldmani*.

From *D. h. tularensis*, it is distinguishable further as follows: Tail proportionately shorter; hairs at tip of tail much shorter (from tip of tail proper, maximum of 9 specimens of *tularensis*, 34 mm., and averaging 15 per cent of tail length; maximum of 11 specimens of *berkeleyensis*, 24 mm., and averaging 12 per cent of tail length); spread of maxillary arches proportionately greater.

The following average measurements indicate to some extent the affinities and divergences of the four races of *Dipodomys heermanni* above considered. For explanation of measurements see Grinnell (*op. cit.*).

	heermanni (CARBONDALE, 2 ♀♀, 3 ♂♂)	*goldmani* (SEASIDE, 5 ♀♀, 5 ♂♂)	*tularensis* (TRACY, 4 ♀♀, 6 ♂♂)	*berkeleyensis* (BERKELEY, (1 ♀, 1 ♂)	*berkeleyensis* (MT. DIABLO, 7 ♀♀, 4 ♂♂)
Total length	287	291	301	301	289
Tail vertebrae	174	178	184	180	173
Length of head and body alone	112	113	117	123	116
Ratio, tail to body	155%	157%	156%	149%	150%
Hind foot	42	42	44	41	42
Ear, from notch (dry skin)	13.5	11.4	10.3	12.5	11.1
Greatest length of skull	39.3	39.1	39.8	39.2	38.3
Breadth of skull across bullae	24.3	24.0	24.6	23.8	23.6
Spread of maxillary arches	22.6	22.2	22.1	22.4	21.7
Greatest length of nasals	14.7	14.4	14.6	14.4	14.2
Greatest width of rostrum near end	3.9	3.9	3.9	4.3	3.7
Width of maxillary arch at middle	5.3	5.1	4.9	4.8	4.7
Length of longest hairs from tip of tail	26	20	28	23	20
Ratio, length of hairs at tip of tail to tail vertebrae	15%	11%	15%	13%	12%

In conclusion, 12 specimens of *Dipodomys heermanni berkeleyensis* were taken on Mt. Diablo. The racial distinction of *berkeleyensis* is confirmed. Comparisons with the nearest related forms were made; and closest affinity appears to be with *goldmani*.—EMMET T. HOOPER, *Museum of Vertebrate Zoology, University of California, Berkeley, California.*

A NEW HETEROMYID SKULL OF THE GENUS CUPIDINIMUS

The occurrence of Tertiary heteromyid skulls is sufficiently rare to warrant a record of each specimen. The Dartmouth College Museum Expedition, 1935, found such a specimen (D. C. M., no. 35-47-3144) on the Willow Creek branch of Rock Creek, northeast of Battle Mountain, Nevada, near the Elko and Lander counties line.

The skull has only one tooth, the left upper premolar. A portion of the palate is in place, and on the right the frontal process of the zygomatic arch. The infraorbital foramen is not well defined, probably due to the breaking of its edges.

After the preliminary work of cleaning, the specimen was sent to Dr. Albert E. Wood for examination. He kindly gave his permission to quote from his remarks as follows: "The skull fits with the subfamily characters I have listed for the *Dipodomyinae* (Ann. Carnegie Mus., vol. 24, pp. 73-363, 1935), and the height of crown of the tooth is within the limits of *Cupidinimus*. The only striking difference of the tooth from *Perogna-*

thoides is the absence of accessory capsules on the protoloph, which is very badly worn on *Perognathoides tertius* and so does not show them. . . . I found almost every one of the *Dipodomyinae* cranial characters in this specimen. . . . I would have no hesitation in referring the skull to *Cupidinimus*, but it seems to belong to a form distinctly larger than *C. magnus*. It is much more advanced than *C. nebrascensis* from the Thousand Creek, but not so far along as *C.* cf. *magnus* from the San Pedro. On this basis, I should consider it as being Middle to Upper Pliocene, and my guess would be upper Middle."

Wood's measurements of this specimen, together with those of other *Cupidinimus* skulls (Wood, *loc. cit.*) are tabulated below.

	C. nebrascensis		*C. magnus*	*C.* sp?
	C. M. No. 10193	C. M. No. 10170	A. M. N. H. 21835	D. C. M. No. 35-47-3144
Aveolar length	1.30	1.50		2.40
Crown length	0.86	1.00	1.30	1.65
Width protoloph	0.55	0.55	1.40	1.19* 1.24†
Width metaloph	1.05	1.12	1.55	1.95* 2.10†

* Grinding surface. † Maximum width.

ROBERT G. CHAFFEE, *Dartmouth College Museum, Hanover, New Hampshire.*

AN ADDITIONAL RECORD OF THE GIANT BEAVER

Cahn (Jour. Mamm., vol. 13, pp. 229–241, 1932; vol. 17, pp. 66–67, 1936) has listed all of the known records of *Castoroides*. This animal is sufficiently rare to make any other records a matter of interest. There is in my possession a femur of this animal, from Nebraska, which, according to Cahn's system of numbering, would be Nebraska no. 5. This specimen was presented to me by Mr. James Quinn of Ainsworth, Nebraska. He collected it several years ago from Pleistocene beds a few miles north and west of Ainsworth. The specimen is complete except for the epiphyses, and measures 12.65 cm. in present length. Associated with it is an astragalus of a beaver, intermediate in size between that of a recent *Castor* and that of *Castoroides*. It probably represents one of the large Pleistocene true beavers, which are well known to exist. A large beaver femur, Amer. Mus. no. 8240, from the late Pleistocene of Fossil Lake, Oregon, likewise is distinctly smaller than that of *Castoroides*, as represented by the present specimen, and probably represents a large *Castor*.—ALBERT ELMER WOOD, *Cape May Court House, New Jersey.*

BURROWING HABITS OF PEROMYSCUS POLIONOTUS

A number of breeding stocks of old-field mice (*Peromyscus polionotus*) were collected in parts of Alabama and Florida in the spring of 1935 for a study of variation. Incidental to the collecting, certain burrows were excavated and notes made on the burrowing habits of the animal.

The form of burrow of this mouse has been noted by Howell (North Amer. Fauna, no. 45, 1921) and by Sumner and Karol (Jour. Mamm., vol. 10, 1929). The typical burrow slants from the entrance to a certain depth; then the tunnel levels off and may continue straight for some distance. A nest chamber is formed at the end of this level portion of the burrow. An "escape tunnel" often rises from the nest chamber almost or quite to the surface. The entire burrow often, but not always, runs in one direction.

The depth of two series of burrows in different localities was measured to the nearest inch. The depth measured was the vertical distance of the bottom of the burrow below

the surface of the ground. Only burrows which seemed to be fairly fresh were investigated. Burrows that did not level off after the initial slanting of the tunnel were not included in the computations, since obviously they were unfinished. No signs of occupation were found in these incomplete burrows.

The first locality where studies were made is on the north shore of Choctawhatchee Bay, at Port Dixie, Okaloosa County, Florida. Here 25 burrows were excavated, only 16 of which were complete and of use in this discussion. These burrows were in a vineyard in which cultivation was neither intensive nor recent. The soil was friable near the surface but compact a few inches below.

The second series of burrows was located at Seminole Hills, about 5 miles northwest of Westbay, Walton County, Florida. Here 10 burrows were excavated, all of them being included in the computations. This location was in an abandoned vineyard. The digging was very easy for a depth of at least 24 inches.

A comparison of the burrows of the two localities shows a difference in average depth. For the Port Dixie series of 16 burrows the mean depth and its standard error is 13.63 $\pm$ .99 inches, the least depth being 7 inches and the greatest 20 inches. At Seminole Hills the series of 10 burrows has a mean depth and standard error of 19.10 $\pm$ 1.39 inches, with a least depth of 12 inches and a greatest of 27 inches. The difference in depth between the two series of burrows is 5.47 $\pm$ 1.71 inches. The difference is 3.2 times its standard error, indicating a statistical significance. This difference seems to be correlated with the hardness of the soil, for at Seminole Hills, where were the deeper burrows, the soil was much more easily excavated than at Port Dixie.

The size of the nest chamber also was quite different in these two localities. At Seminole Hills the nest chambers all were between 4 and 7 inches in diameter, while at Port Dixie the chambers were much smaller, all being less than 2 inches in diameter, some having no distinct chambers. Why the nest chamber varies so much in size is not apparent. The softer, looser soil may cave in to a greater extent, or the mouse may find the harder, more compact soil more difficult to excavate.

Burrows of this mouse may be found with the entrance either open or plugged. It is a general fallacy in this region that open burrows do not contain mice (Sumner and Karol). I believe that an explanation for this plugging of the burrow mouth is indicated by certain observations made at Crystal Lake, Washington County, Florida. Here some burrows were excavated one day and all were found to be open at the mouth. The next day a rain interrupted the work of digging. After the rain many of the remaining burrows were found to be rather solidly plugged for from 6 to 12 inches from the mouth. At this time every one of 8 holes having this solid plugging contained one or more mice. Open holes occasionally contained mice, but usually they did not. Certain burrows were found which had been washed shut with sand by the rain, but this type of plug was not solid and extended only for a couple of inches. None of these holes contained mice. Possibly those holes into which the water ran were quickly plugged by the mice, and in those cases where inhabited open holes were found following the rain, the water had not entered.—Don W. Hayne, *Laboratory of Vertebrate Genetics, University of Michigan, Ann Arbor, Michigan.*

THE GOPHER MOUSE—PEROMYSCUS FLORIDANUS

Several individuals of *Peromyscus floridanus* were found occupying the burrows of gopher turtles in an old field 4 miles east of Gainesville, Florida. On the night of June 8, 1935, about 20 of these burrows were examined with the aid of flashlights. They extended at an angle of about 35 degrees for several feet and varied considerably in size, the average being about 12 inches wide and 8 inches high. The condition of the sand about the entrances indicated that at the time the burrows were inhabited by gopher turtles. Three burrows contained 2 mice each, and one mouse was seen in each of two

other holes. The mice were about 6 feet within the entrance, and at that level one individual appeared to enter a small side hole. A snap trap set about one foot within a burrow for 30 minutes captured one immature mouse. Gopher frogs, which also inhabit the holes of the gopher turtle, were found in and near some of the burrows, but were not observed in those in which mice were found.

We consider it desirable to establish distinctive common names for small mammals, and in consequence of the relationship sometimes existing between this mouse and the gopher turtle, we suggest the use of gopher mouse as the common name of the species, *Peromyscus floridanus*. This is preferable to the name Florida deer-mouse, now sometimes used for the species, because the term deer-mouse has been widely used to designate other species of this genus, and because two other Florida species of *Peromyscus* have an equal right to be called Florida deer-mice.—W. Frank Blair, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan, and* John D. Kilby, *Department of Biology, University of Florida, Gainesville, Florida.*

THE PINE MOUSE RECORDED IN NEW HAMPSHIRE

During the fall of 1935, a series of pine mice of the form *Pitymys pinetorum scalopsoides* was collected by the writer in a second-growth mixed hardwood area in the town of Durham, New Hampshire. As far as he can ascertain, this is the first record for the state, and is an indication that the range of this mouse is extending northward. The specimens are in my collection.—W. Robert Eadie, *Department of Zoology, University of New Hampshire, Durham, New Hampshire.*

A NEW SPECIMEN OF SYMBOS FROM CHICKASHA, OKLAHOMA

In 1928, a fragment of a skull of *Symbos* was uncovered in a Pleistocene sand pit at Chickasha, Oklahoma, and placed in the Museum of Vertebrate Paleontology (U.O.M. V.P. no. 646) at the University of Oklahoma. This by no means is a new discovery for the state, as Fort Gibson, Oklahoma, is the type locality of *Symbos cavifrons*. The type of the latter is an imperfect specimen (Leidy, J., Smiths. Contr., vol. 53, pp. 12–17, 1853). Hay (Proc. U. S. Nat. Mus., vol. 58, p. 125, 1920) also described a specimen of *Symbos promptus* from near Afton, Oklahoma. In 1924 (Hay, Carnegie Inst. Wash., Publ. no. 322A, p. 178), he listed a fragment of a skull of *S. cavifrons*, found 15 miles north of Fort Smith, Arkansas, and now in the St. Louis Academy of Science.

The specimen under present consideration consists only of a fragment of the dorsal part of the skull. The right horn has been removed completely, but the base of the left horn core remains intact. The nasals, orbits, maxillaries, and occipitals all have been removed. In comparing this fragment with the skull of *Symbos*, however, there can be no doubt regarding its identity. Enough of the left horn core remains to indicate that the horns had a uniformly downward curvature, rather than an abrupt one as is characteristic of *Ovibos*. Fusion of the two horn cores at base in this specimen is another definite character of *Symbos*, as is the extreme depth of skull through the braincase and its relative narrowness. The writers feel that the specimen is too incomplete to permit allocation to a definite species, but since all the characters present correspond with those of *S. cavifrons* (Allen, J. A., Mem. Amer. Mus. Nat. Hist., n.s. vol. 1, pt. 4, pp. 101–226, 1913), in all probability it is of that species.

This specimen is of importance because it extends the range of the genus 1 degree south and 3 degrees west. It cannot be concluded from this fact, however, that the animal actually ranged quite this far south and west, because the fragmentary condition of the skull and the circumstance that it was recovered from what probably is a former stream bed, suggest that it may have been transported by water to the site of its recovery. Uncomfirmed reports of finds in Texas caverns, however, indicate that the genus may have ranged well into that state.—J. Willis Stovall and J. Teague Self, *University of Oklahoma, Norman, Oklahoma.*

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COMMENT AND NEWS

One of the activities of the American Committee for International Wild Life Protection is the accumulation and publication of reports, information on legislation, and kindred matters regarding interesting species of mammals whose present status is a cause for concern. Not infrequently these publications are translations from languages in which very few of us are proficient, and thus we are apprised of conditions about which we otherwise would remain in ignorance for an extended period.

A pamphlet of this sort (Nature Protection in the Netherlands Indies, Spec. Publ. Amer. Comm. Internat. Wild Life Protect., no. 8, 1936) from the American Committee, recently received, gives the welcome information that through the Nederlandsche Commissie voor Internationale Natuurbescherming, a study of the extremely interesting and in many ways unique fauna of the Netherlands Indies has been made, and recommendations offered for its suitable perpetuation.

It is a cause for congratulation that one country after another is recognizing the need for drastic action if the more unique features of its wild life are to be preserved for posterity. Most of the plans recently considered and those adopted for the perpetuation of foreign species impress one as being biologically sound and desirable. On the contrary, it is a cause for the deepest concern that in the United States the majority of the plans most advertised as cures for our wild life ills, and on which much money is being spent, are of utopian character, some of them actually harmful to wild life, and others foredoomed to failure because biologically unsound.

Among recent governmental activities intimately concerned with wild life, are projects in Idaho, Montana, Oregon, Utah, and Wyoming, on which there are 250 WPA men engaged in hunting and trapping for predatory animals. This is an average of 50 men for each of the above five states, and it is safe to infer that considerable of the "hunting" involves the following of poison lines. The difficulty, if not the impossibility, of securing this number of men properly qualified, in a biological sense, to undertake this sort of work is self-evident, and the fact that the actions of such trappers in the field cannot be controlled even by talented supervision was demonstrated during the investigation conducted by the American Society of Mammalogists several years ago. An additional regrettable item is the fact that these hunters are permitted to retain and to sell the furs of the predators taken. Naturally they will class as a predator every animal whose pelt is of commercial value.

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